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Robert Moses State Park

Field 2 Bathhouse Design Recommendations

A Major Qualifying Project Report
Submitted to the Faculty of
Worcester Polytechnic Institute
In partial fulfillment of the requirements for the
Degree of Bachelor of Science
In Civil Engineering and Architectural Engineering
By:

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Stantec

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Abstract

Completed in collaboration with Stantec, this project analyzes the proposed architectural and structural renovations for the Robert Moses State Park Field 5 Bathhouse and provides alternative designs to improve the performance, cost and construction that may be applied to the upcoming renovation of a similar structure. Architectural alternatives were proposed for the building envelope, public shower areas, and exterior aesthetic based on energy analysis and accessibility codes. Structural designs were recommended for the roof, slab, grade beams, and pile caps according to structural analysis and code requirements.

Capstone Design Statement

Robert Moses State Park has five public bathhouse facilities. Stantec has provided the design for renovations on the Field 5 facility. The client, New York State Office of Parks, Recreation, and Historic Preservation (OHR&HP), is considering renovations at a second bathhouse. The objective of the project is to analyze the Field 5 Bathhouse plans for structural integrity and energy consumption and to provide alternate designs for the similar Field 2 facility. The intent of the alternate designs is to provide Stantec with designs that address various constraints within the project, such as cost savings, energy savings, geometric considerations, and code compliance.

The architectural design process began with evaluating the existing conditions and layouts. An energy model of the existing Field 5 Bathhouse was created using eQUEST building energy simulation software. The Stantec proposed design was also modeled to compare its performance to the baseline and analyze energy consumption. Based on the energy analysis, design changes were analyzed in eQUEST and recommendations were made for the Field 2 facility. Additionally, alternative public shower area layouts were developed using an iterative process according to design, code, and space requirements. An alternative higher-end exterior aesthetic was also proposed to meet economic constraints and client preferences. The bathhouse was modeled in Revit so the client could visualize the renovations.

The structural design process began with analysis of the structural design components proposed by Stantec. Calculation sheets for slabs, grade beams, pile caps, and piles were created to determine the design capabilities. The roof structure was analyzed using Autodesk Robot Structural Analysis, and this structural model was used to develop an alternative wood truss solution. After preliminary analysis of the various components, an iterative process was used to establish an alternative design based on specified assumptions and design requirements. If the new design failed analysis, new assumptions were developed and reanalyzed.

Design Constraints

Economic

The Robert Moses State Park Bathhouse renovation project focused on improving the designs proposed by Stantec while considering the cost of the various options. Each structural design was economically compared to the design proposed by Stantec. Reference cost data was obtained from

RSMeans Heavy Construction 2014 (RSMeans, 2014). The economic impact was also considered throughout the architectural design process by weighing the options for energy savings versus initial cost.

Environmental

The environmental considerations within the project included reduction of heating and cooling by optimizing the energy efficiency of the building. Additionally, the reduction in material usage for some of the designs was considered for the recommendations.

Ethical

The engineering design of the project followed the ethics set forth by the National Society of Professional Engineers. Safety, health, and welfare of the public were held to the highest standard.

Health and Safety

The structural designs within the project followed local building code provisions, as well as the relevant requirements established by the American Concrete Institute (ACI), Precast/Prestressed Concrete Institute (PCI), and the National Design Specification for Wood Construction (NDS). These documents ensure that the designs are safe and effective means of infrastructure. In addition to safety, the structural designs account for comfort of the occupants by providing adequate deflection and cracking control for concrete components. The architectural alternative layouts complied with the local building code provisions, including accessibility requirements per ICC/ANSI A117.1 to ensure accessibility and safety within the building. The comfort and well-being of occupants within the building was also considered through analysis of the energy model.

Manufacturability

The manufacturability and constructability of the components were important considerations in preparing and addressing structural design alternatives. The component alternates are intended to provide a practical balance between ideal design and constructability/manufacturability. This includes, but is not limited to, using similar sized rebar and maintaining consistent dimensions among similar components.

Sustainability

The architectural design of the project improved the building envelope, day lighting, and sources of renewable energy to increase energy efficiency of the building. The structural design of components considered the longevity and durability of each component as a factor in the design process, as well as design alternates that reduced the amount of material needed for the project.

Professional Licensure Statement

The Profession Engineer (P.E.) licensure is a certification that a qualified, practicing engineer will work to meet or exceed all necessary regulations, design standards, and ethical standards. The P.E. licensure allows an engineer to approve a design with a seal and signature, denoting that the design meets or exceeds all codes, regulations, and requirements. This responsibility and capability lies solely with a professional engineer.

The requirements to obtain P.E. licensure as a civil engineer begins with graduating from an ABET- accredited program. After passing the Fundamentals of Engineering (F.E.) exam, the state minimum number of years of experience practicing engineering is needed. The Engineer in Training (E.I.T.) must work under the direct supervision of a P.E. during this time and build a portfolio of experience. Once the E.I.T. completes the state minimum number of years under a P.E., they may apply to take the Professional Licensure exam, at which point the applicant's portfolio is reviewed. Upon approval, the applicant must pass the exam, which is rigorous and tests the engineer's capabilities in their engineering discipline. The P.E. license and seal is awarded upon passing the P.E. exam.

A professional engineer must maintain licensure by paying annual dues to renew the license. Furthermore, the P.E. must continue to practice ethical and responsible engineering within their discipline. A continual learning approach is necessary to provide the highest quality and most up-to-date design methods throughout the career of a professional engineer.

The P.E. licensure ensures the civil engineering profession maintains a high level of quality work. It is beneficial to the public by providing the highest quality of licensed engineers signing off on projects that may have significant societal impacts.

Authorship

This paper has two major topics throughout: Architectural engineering and structural engineering.

Chris was responsible for the *Structural Design of Field 5 Bathhouse* section of the Background chapter as well as the Design Statement. Chris was also responsible for the Structural Results and worked with Rachel on Chapter 1 Introduction and Chapter 4 Conclusion.

Rachel was responsible for the content of *Overview of Field 5 Bathhouse, Architectural Design of Field 5 Bathhouse and Sister Bathhouse: Field 2* sections of the background. Rachel was responsible for the Architectural Results and worked with Chris on Chapter 1 Introduction and Chapter 4 Conclusion chapters.

Christopher Flanagan (Civil Engineering)

Rachel Kennedy (Architectural Engineering)

Acknowledgements

We would like to thank our advisors Professor Leonard Albano and Professor Steven Van Dessel for their guidance and feedback; Dr. Kemal Sarp Arsava for his help in the topic of prestressed concrete; Professor Ali Fallahi for his assistance with the energy modeling; and Professor LePage and Professor Hart for providing us with the opportunity to work at this project center, as well as their feedback in the proposal stage of the project.

We would like to thank Jeff Cohen for working with us during our seven weeks at Stantec, and for always making himself available as a resource for the project; Mike Travers and Chris Farrington for their help with eQUEST and energy modeling; and all others in the office who welcomed and assisted us with the project.

Lastly, we would like to thank our sponsor, Stantec, for providing the project as well as workspace and resources in their Burlington, MA office.

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Executive Summary

Robert Moses State Park is located on Fire Island (Long Island), Babylon, New York. As a victim of multiple hurricanes and tropical storms, the facilities at the park have been battered in recent years. The New York State Office of Parks, Recreation, and Historic Preservation (OPR&HP) hired Stantec to design the renovations for the most popular facility, the Field 5 Bathhouse. As of January 2016, Stantec submitted the final 100 percent design documents for this facility. However, the Field 2 facility is likely to be renovated in the near future, allowing for design alternatives to be explored.

The objective of this project was to provide analysis and insight on the design for the Robert Moses State Park Field 5 Bathhouse as provided by Stantec. The analysis of the current design led to alternative design recommendations that can be used for the similar Field 2 facility, slated to be renovated in the coming years. The result is a series of design alternatives that are focused on enhanced constructability, economy, or sustainability.

The architectural scope of work for the Field 5 Bathhouse renovation has three main parts: 1) to perform an energy analysis of the Field 5 Bathhouse; 2) to design an alternative layout for the women's and men's public shower structures; and 3) to develop a higher-end exterior aesthetic for the facility.

Stantec's proposed renovations of the bathhouse give a performance energy savings of 15.8 percent and cost savings of 16.1 percent over the baseline building. This performance meets the 10 percent prerequisite for sustainable renovations of existing buildings in New York as specified in EO 111. Design recommendations were evaluated to find cost-effective alternatives to reduce the energy consumption of the Field 2 Bathhouse. Analysis focused on building envelope design alternatives including improved wall insulation to R-13.3 and roof insulation to R-25 and increasing the use of solar panels. The improved building envelope resulted in performance energy savings of 20.8 percent and a cost savings of 21.1 percent relative to the baseline model, and performance energy savings of 5.9 percent and cost savings of 6.0 percent compared to Stantec's proposed design. Therefore, it is recommended to increase the insulation within the wall and roof. Increasing the area of solar panels across the entire ocean side roof and both sides of the roof on the dining area provides a 96.9 percent electricity cost reduction relative to Stantec's proposed design. As a result, it is strongly suggested to increase the area of solar panels.

Alternative layouts were created for the women's and men's public shower areas to increase shower capacity, to increase the number of toilets in the women's area, and to increase the supplies storage area in the men's structure. The proposed alternative design for the women's shower area increased the total number of fixtures without expanding the size of the structure, making it the recommended design for future bathhouse renovations. While the men's layout increased the supplies storage area by 2.5 percent, the dividers between the showers were changed from Stantec's proposed brick dividers to the existing solid phenolic partitions to fit the showers along the width of the structure. Therefore, it is suggested that Stantec's proposed design be used for the men's shower structure area on future renovation projects.

Based on the client's desire for a low-cost, alternative aesthetic, three beach facilities were considered for inspiration for the design of the Field 2 Bathhouse. The resulting proposal includes brick along the bottom perimeter, lap siding, and shingles across the top. White wood trim separates the different materials and mullions are placed in the top windows, creating a coastal-theme architectural look. At the same time, the remaining brick masonry helps incorporate the new design into the existing Robert Moses Park architecture.

The structural design alternatives focused on four components: the roof structure, the slab, the grade beams, the pile caps, and the piles. Alternative designs were developed based on design constraints as outlined in their respective sections of the Results chapter. A table provided at the end of the summary includes the cost comparison of each structural design alternative.

Two alternatives were prepared for the roof structure. The first alternative design is a truss framing spaced 8 feet on center. The main chords are 6" x 10" timbers. The second alternative design is glued laminated framing. The framing consists of 2" x 12" 3-ply glued laminated lumber for the rafters spaced 24" on center. The two alternative designs were compared to the proposed design of 2" x 14" framing that is 16" on center. The truss alternative was ruled out due to the inability to increase the clear height in the attic, as well as a significant increase in cost. The engineered glued laminated lumber was also ruled out due to significant cost increase over the use of dimension lumber. The recommendation is to use the proposed design for the roof framing, unless the clear height of the glued laminated option is important enough to justify the cost increase.

The slab design alternatives include a 6-inch slab with the addition of two grade beams as well as an 8-inch slab with no additional grade beams. The design goal was to meet the minimum ACI span length to avoid deflection calculations. The detailed consideration of slab deflection includes creep effects and many variables that may change throughout the use of the building. The ACI requirement for slab thickness based on the slab span length reduces the impact of deflection over the life of the slab. The 6-inch slab with two additional grade beams meets the ACI requirement and is more economical than simply increasing the slab thickness.

The alternative grade beam designs contain an option to maintain the 30-inch depth of the grade beams and an option to reduce the depth of the grade beams. The latter option meets the ACI 318 requirements for shear and deflection with the provided reinforcement design. In addition, the reduced size saves on material cost versus the 30-inch beams from the first alternative design.

The alternative pile cap design maintains the same dimensions as the proposed design, which is the minimum size for a pile cap with two 12" piles. The design provides an alternative reinforcement design shown in Figure 29 in the Structural Results section. Due to the alternative design only having a different reinforcement design, the cost of the alternative pile cap is regarded as the same as the proposed design.

The alternative pile design includes both a prestressed and a precast/cast-in-place option. The piles for both options are 40 feet in length and 12" diameter. The reinforcement and strand layouts are found in the Pile Design section of the Structural Results chapter. The precast/cast-in-place pile system provides the necessary strength and will provide a longer lifespan than the proposed timber pile. The prestressed pile is not justified due to its cost compared to that of the precast/cast-in-place and the timber piles.

The architectural and structural design recommendations provide alternative solutions for Stantec that take into account various design considerations for the bathhouse facility. The emphasis throughout the design was on the considerations of the client, OPR&HP. The design accounted for project cost, building usage, and codes and regulations to recommend alternatives that can be implemented in future bathhouse renovations at Robert Moses State Park.

Component	Option	Description	Project Cost
Roof	Stantec Design	2x12 at 16" oc	$9,500
	Timber Truss	See Appendix	$30,000
	Engineered Lumber Rafters and Ridge Posts	40' clear span at 16' oc	$20,000
Slab	6 in	Normal Wt. #5 rebar	$10,500
	6 in w/ Add. Beams	Normal Wt. #5 rebar	$13,000
	8 in	Normal Wt. #5 rebar	$15,000
Grade Beam	Stantec Design	See Appendix	$4,000
	Alt. 1	Same Size, Alt. Rebar	$4,000
	Alt. 2	Smaller Size, Alt. Rebar	$3,000
Pile Cap	Stantec Design	See Appendix	$14,000
	Alt. 1	Same Size, Alt. Rebar	$14,000
Pile	Timber	12" Round	$30,000
	Precast Concrete	12" Round	$40,000
	Prestressed Concrete	12" Round	$50,000

1 Introduction

Robert Moses State Park is located on Fire Island (Long Island), Babylon, New York. The facilities at the park have been battered in recent years by multiple hurricanes and tropical storms. The New York State Office of Parks, Recreation, and Historic Preservation (OHR&HP) hired Stantec to design the renovations for the most popular facility, the Field 5 Bathhouse. As of January 2016, Stantec had submitted the final 100 percent design documents. The Field 2 facility is likely to be renovated in the near future, allowing for design alternatives to be explored.

The objective of this project is to provide analysis and insight on the design for the Robert Moses State Park Field 5 Bathhouse as provided by Stantec. The analysis of the current design led to alternative design recommendations that can be used for the similar Field 2 facility, slated to be renovated in the coming years. The result is a series of design alternatives that are focused on improved constructability, economically, or sustainability. The analysis and design of the structural and architectural improvements is categorized by component or section associated with the building.

The architectural components for the Robert Moses State Park renovation project included energy analysis of Stantec's proposed renovations for the Field 5 Bathhouse, design recommendations for reducing energy consumption at the Field 2 facility, alternative layouts for the women's and men's public shower areas, and an alternative higher-end aesthetic design. The energy analysis was completed using eQuest building energy simulation software, and the alternative designs followed local building code provisions, including accessibility requirements per ICC/ANSI A117.1.

The structural design includes the roof structure, the concrete floor slab and supporting grade beams, the pile caps, and the foundation piles. The design complies with the local building code and uses the American Concrete Institute (ACI), Prestressed Concrete Institute (PCI), and National Design Standards (NDS) methods and standards. In addition, structural software was used for analysis and design.

Both the architectural and structural components were incorporated into a building information model to ensure compatibility and consistency between the designs. The model created in Revit also served as a visualization tool for the client.

The next chapter of this report provides the background of the project, defining Stantec's scope of work for the Field 5 Bathhouse renovation, the architectural scope of work for this project, the structural design components covered in this project, and the Field 2 facility that the client plans to renovate in the upcoming years. Chapter 3 includes the results of the architectural and structural components followed by the design process. The alternatives are compared and recommended in Chapter 4 of the report.

2 Background

Robert Moses State Park is roughly five miles of beach along the shore of Fire Island (Long Island), New York where visitors swim, surf or fish. The park welcomes approximately 3.5 million guests each year, with its peak season from just prior to Memorial Day weekend through Labor Day. During the early spring and late fall, the four bathhouse facilities within the State park are partially open to fisherman from sunrise to sunset. These four bathhouses, known as Field 2, 3, 4, and 5 Bathhouse, are identified in Figure 1 and located less than a total of a mile apart. They offer food, equipment rentals, restrooms and changing rooms, picnic tables, and park information. At the main bathhouse, Field 5, there is also a children's playground.

Figure 1 Robert Moses State Park with Bathhouses

2.1 Overview of Stantec's Design Renovations for Field 5 Bathhouse

The Field 5 Bathhouse building was designed in September 1970 and is presumed to have opened within the next 18- to 24-months (Basis of Design, 2015). The bathhouse building is fully operational during the summer months; only the public toilet room facilities located in the main building are available when it is partially open in the off-season. In the winter months it is closed, with the exception of the two public toilet rooms, power systems are shut off, and water is drained to prevent pipes from freezing.

The existing facility is a two-story, pile-supported T-shaped building with detached locker/shower structures on the east and west sides. Floors are concrete slab-on-grade, and walls are constructed of concrete masonry, structural glazed tile, and brick masonry. The roof structure is wood-framed with wood sheathing and architectural-grade asphalt shingles.

Some renovations and alterations were completed in the facility since its original construction. These include, but are not limited to, kitchen layout and equipment upgrades; renovation of the "office toilet/shower room" into a storage room; installation of a wheelchair accessible toilet stall and lavatory in the men's and women's public toilet rooms; and replacement of the boiler and fuel oil storage tank.

Stantec has been working on the Robert Moses State Park project for the last two years. Original design work was focused on renovations for Field 2 Bathhouse before the client decided to repair Field 5 Bathhouse first. The scope of the Stantec Field 5 Bathhouse project includes renovations, new construction, and site work to meet the requirements set forth by the New York State Office of Parks, Recreation, and Historic Preservation (OPR&HP). Elements of the building renovation and new construction are listed below in Table 1.

Table 1 Stantec Field 5 Bathhouse Project Scope

Renovations	New Construction
All interior spaces, with limited renovations in kitchen, kitchen janitor closet, cash room, dry storage room, walk-in refrigerator and freezer, dining area, and concessions service counter area	Installation of building fire alarm system
Exterior building renovations including replacement of existing fenestration (doors and windows) and localized masonry repairs	Structures for expanded public shower/toilet facilities
Public toilet rooms with architectural and MEP upgrades	Porticos over pass-through walkways
Staff toilet rooms with architectural and MEP upgrades	
First Aid Office and Area Office with architectural and MEP upgrades	
Replacement of MEP system	

To address the project scope above, Stantec defined the following eight objectives:

1. Upgrade public toilet room facilities
2. Provide new structures for men's and women's shower areas
3. Upgrade exterior envelope fenestration
4. Remove and replace Mechanical, Electrical and Plumbing systems
5. Provide Interior Renovations/Repairs
6. Abate all regulated hazardous materials impacted by the renovation work
7. Provide limited site work
8. Conduct a solar photo-voltaic system assessment/study

The 100 percent design for the Field 5 Bathhouse was submitted near the start of this project (1/14/2016). All of the project design was based on criteria established by OPR&HP, New York State codes and referenced national codes. Construction has not yet started on the site. An overview of the eight objectives is provided in the next sections.

2.1.1 Upgrade Public Toilet Room Facilities

This objective involves a gut renovation of the public toilet room facilities. Main tasks are to improve ventilation within toilet rooms and provide mechanical systems to keep floors dry and prevent condensation from forming. The upgrades also include new water-conserving fixtures, electrical systems, architectural finishes and specialties.

The floor slab and suspended plaster ceilings will be completely removed, while the existing glazed structural tile partitions will be removed only as required to accommodate the installation of new mechanical, electrical and plumbing utilities. New plumbing drains will be installed as well as a radiant floor heating system to prevent condensation from forming on the floors. The replacement floor slab will be similar to the existing slab and include a concrete topping layer (sloped to drains) with a ceramic mosaic floor tile. In place of the current ceiling, a new suspended gypsum board ceiling will be installed.

As part of the effort to conserve water and be more cost-effective, water-conserving plumbing fixtures will be installed. The water closets will be 1.28-gallon per flush, and all lavatories will be equipped with 0.5-gallon-per-minute aerators. New waterless-type urinals were not recommended because of the high occupancy and usage of the facility; instead, ultra-low-flow type urinal flush valves will be used at 0.13-gallon per flush.

All walls will be finished with 6-inch-square glazed ceramic wall tiles mud-set over a 1½-inch-thick mortar bed. These walls, the toilet partitions, mirrors, and similar features shall be vandal-resistant.

2.1.2 Provide New Structures for Men's and Women's Shower Areas

The existing detached men's and women's shower areas will be demolished with the objective of providing new structures to suit OPR&HR requirements. OPR&HR requested that the men's shower area structure house the men's public showers and dressing cubicles, the beach umbrella & beach chair storage/distribution space, and a supplies storage room for maintenance equipment and site furnishings. Stantec met the layout requirements for this new structure by designating approximately one-third of the area for the shower and changing stalls and two-thirds of the area for storage. For the women's shower area, the primary objective was to provide additional public toilets in a fully-enclosed building and if possible, additional showers. The structure will also house the women's public showers and dressing compartments, a public women's toilet room, and a janitor closet with utility sink.

Stantec proposed three alternative designs to OPR&HP for the detached shower areas. Alternatives 1 and 2 were designed within the 33'-4" x 44'-4" footprint of the existing structure, while alternative 3 increases the women's structure by 467 square feet and the men's structure by 333 square feet by expanding 14-feet in the eastward direction and 10-feet in the westward direction, respectively. All three designs include: new plumbing layouts to match architectural changes; new cold water, hot water, waste and vent pipes to accommodate the new plumbing features; and new area drains and drainage systems to accommodate the altered layout in both the men's and women's shower areas. Although all three alternatives meet the design requirements, each option presents different ways of increasing the fixture count, which are summarized below in Table 2.

The upgrades in the men's shower area for all the designs will be the removal of the bathroom section to accommodate the increased storage space, as well as the increased number of shower heads. In the women's shower area, the restroom section will be expanded, while the shower/changing area will be decreased. Bath new structures include a public, unisex family restroom.

Table 2 Detached Shower Area Design Alternatives

	Existing Conditions	Alternative 1	Alternative 2/2A	Alternative 3
Public Shower Stalls (Men's/Women's)	8/8	10/10	9/9	10/10
Public Dressing Cubicles/Compartments (Men's/Women's)	12	5/7	6/7	9/8
Supplies Storage (Men's)	0 gsf	658 gsf	763 gsf	873 gsf
Beach Umbrella & Beach Chair Storage Distribution (Men's)	0 gsf	153 gsf	108 gsf	210 gsf
Toilet (Women's)	2	9	13	19
Lavatories (Women's)	1	5	7	12

OPR&HP selected alternative 2A. This option was cost-effective since it did not expand the shower structure, while providing the most number of toilets for the women's facility and storage are for the men's structure. Therefore, the main bathhouse roof will be extended over the shower area structures.

2.1.3 Upgrade Exterior Envelope Fenestration

Stantec split the exterior envelope fenestration upgrade into two main tasks: remove and replace existing exterior doors and windows, including dining area doors and windows, and perform masonry (brick) repairs where required.

Doors and windows will be replaced with hurricane-resistant units suitable for waterfront application, as well as vandal-resistance construction. The door assembly shall be composed of fiber-reinforced plastic (FRP) doors and frames with brass hardware. Windows shall consist of vinyl-framed assemblies with polycarbonate glazing. The storefront of the dining area will consist of fixed and operable glazing and opaque glazing infill panels with powder-coated stainless steel framing.

Localized masonry repairs will re-point deficient mortar joints and replace damaged face brick, where necessary. The exterior storefront wall will be renovated to reduce storm damage. A masonry assembly consisting of two-wythes of reinforced red face brick will be placed along the base of the wall. New Polycarbonate-glazed fixed windows in FRP frames will replace the existing windows. The existing full-light glass doors will be replaced with full-glass FRP doors in FRP frames. On the south-facing dining wall, the vertical board siding will be replaced with smooth, composite, beveled lap siding, painted.

2.1.4 Remove and Replace Mechanical, Electrical and Plumbing Systems

The goal of this objective is to remove and replace deficient Mechanical, Electrical and Plumbing systems with energy-efficient, resource-conserving, durable, low maintenance systems. In addition, due to the coastal environment, all the mechanical equipment located outside shall be rust protected (coated).

The existing heating and ventilation systems and equipment are assumed to be part of the original construction and appear to not operate; they shall be removed and replaced. In addition to providing a new mechanical system, there will be an upgrade in the type of fuel serving the building from #2 fuel-oil to liquid petroleum gas (LP gas). The heating and ventilation system will consist of new LP gas-fired condensing boilers to serve the main bathhouse and women's shower area; a hot water heating and ventilation unit (H&V unit); in-line hot water centrifugal pumps; a brazed plate heat exchanger; an underground propane tank; exhaust fans; and air-conditioning for the first aid office only.

The electrical design work includes upgrading all existing distribution panels, interior and exterior lighting systems throughout the interior, and installing telephone and internet lines. The proposed design strives to conserve energy by providing motion-sensor controlled lighting in public spaces and office area. Emergency lights will also be placed throughout the facility, except in the concessions area. A fire alarm system will be installed in the entire bathhouse that complies with the provisions of NFPA 72.

The existing plumbing fixtures, excluding those in the kitchen area, will be removed and replaced with low-flow and water-conserving fixtures, described in the "upgrade public toilet facilities" section. In addition, the existing brass and copper piping will be replaced and used to connect the new water heaters and a domestic water distribution system to existing sinks in the kitchen area. Only tempered water, in the mid-80's degree-F range, will be provided to serve the public toilet room lavatories and public showers.

2.1.5 Provide Interior Renovations/Repairs

This objective includes cosmetic renovation to the staff office. The finishes of the office shall be repaired or replaced as necessary. The existing concrete masonry units, as well as the interior plaster partitions, will be repaired where damaged. Any partitions that obstruct the new mechanical, electrical, and plumbing utilities will be demolished and replaced. The floor slab in the office will remain, only to be repaired where necessary. In addition to the concrete repair work, the surfaces of the slab shall be refinished with an epoxy coating. A suspended ceiling with a plaster finish will also be installed in the staff office.

The first aid office will receive similar treatment to the staff office. The first aid office also includes a toilet room that will be renovated per the toilet room specifications.

2.1.6 Abate all regulated hazardous materials impacted by the renovation work

An interstitial space exists between the attic floor framing and the first floor ceiling. Piping within this space is insulated with a regulated asbestos-containing building material. As a result, all insulation and other materials within this space that are impacted by the work must be abated before work can begin. To access this space, ceilings shall be removed.

Any lead-based paint on site shall be removed prior to construction. The Basis of Design submitted by Stantec contains the list of materials containing asbestos.

2.1.7 Provide Limited Site Work

The site work of the bathhouse project shall include spot repairs to the concrete. Additionally, modifications to the sanitary system will be performed. The shower areas will drain to cesspools instead of the septic tank, and a new underground LP gas tank will be installed. Additionally, new foot wash stands shall be installed on site.

Landscaping is included in the scope of the site work. Plants will be located at the front of the building on both the east and west sides. The plans show the location of stonework and curbing, as well as a planting schedule.

2.1.8 Conduct a solar photo-voltaic system assessment/study

A solar photovoltaic assessment was performed to determine the optimal location and arrangement of solar PV on the building. However, it is no longer in Stantec's Scope of Contract, and the design of a solar PV arrangement was contracted out to another company. The building currently has two arrays of twenty-one solar PV panels on the South-side of the main bathhouse and OPR&HP is planning to add more solar panels to the expanded roof area.

2.2 MQP Scope: Architectural Design of Field 5 Bathhouse

The architectural scope of work for the Field 5 Bathhouse renovation has three main parts: 1) to perform an energy analysis of the Field 5 Bathhouse; 2) to design an alternative layout for the women's and men's public shower structures; and 3) to develop a higher-end exterior aesthetic for the bathhouse.

2.2.1 Energy Conservation Recommendations

New York State Executive Order No. 111 requires regular reporting and overall energy and sustainability improvements. OPR&HP strives to implement measures into its facilities that address the guidelines and goals laid out by EO 111. While EO 111 does not directly apply to the bathhouse renovation, Stantec proposed design solutions to achieve key goals under EO 111 and OPR&HP's energy-conservation goals.

Two energy models – one of the existing conditions of Field 5 Bathhouse (baseline) and a second of the Stantec design of Field 5 Bathhouse (proposed design) – were created to determine the improved energy efficiency in the renovation designs. Based on the energy analysis, design recommendations were made for the future renovation of Field 2 Bathhouse to reduce energy consumption further. Consistent with the building usage description provided in section 2.1 Overview of Stantec's Design Renovations for Field 5 Bathhouse, simulations were run with custom schedules that reflect the actual bathhouse summer and limited off-season use, which differs from a typical building yearly operational schedule.

2.2.2 Alternative Layout for the Women's and Men's Public Shower Structures

Stantec proposed three alternative designs for the detached shower areas to meet the OPR&HP design requirements mentioned above in Upgrade Public Toilet Room Facilities. The selected layouts expanded the women's and men's shower structures 14 feet to the east and 10 feet to the west, respectively. The structures were expanded for two reasons: to include an individual family restroom and for stairs up to the attic. These stairs became a requirement of the extended attic to meet egress travel distance codes.

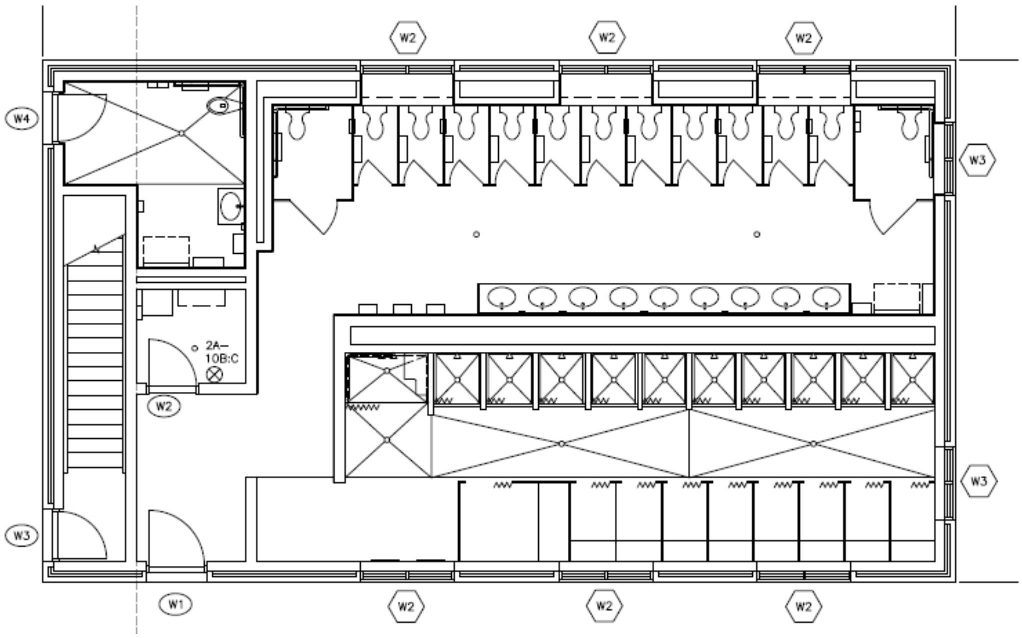


Figure 2 Stantec Design for the Women's Public Shower Area

Figure 2 shows Stantec's design for the women's public shower area. Per the request of OPR&HP, the number of fixtures in this area was increased. The layout includes 11 shower stalls, 9 dressing cubicles, 13 water closets, and 9 lavatories separated into the toilet area and shower & dressing area. A benefit of the vestibule is the privacy it provides from the outside.

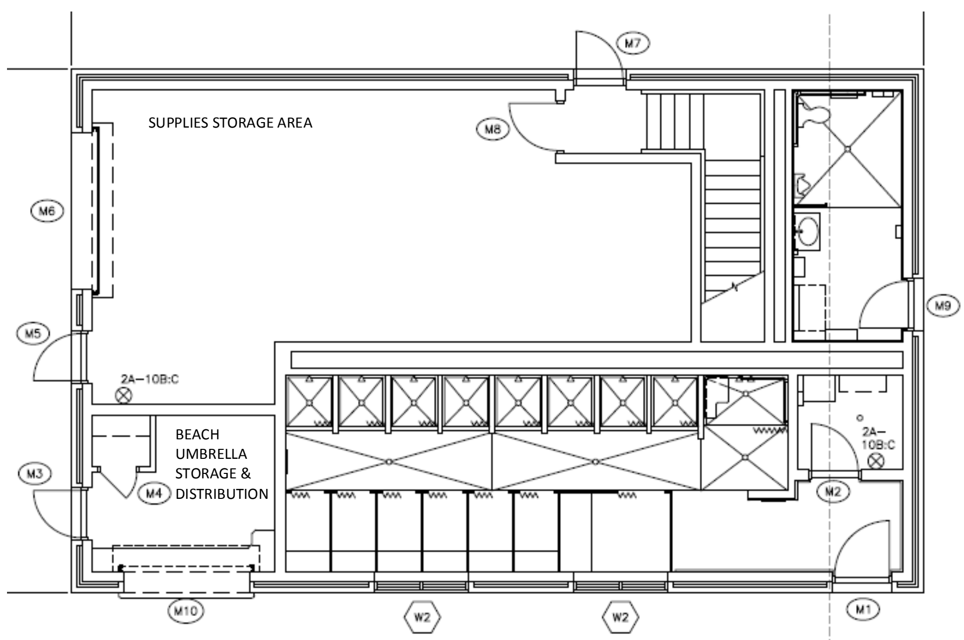


Figure 3 Stantec Design for the Men's Public Shower Area

As can be seen in Figure 3 in the men's shower area, the 9 shower stalls and 7 dressing cubicles are aligned to limit the number of plumbing walls and the chance of pipes freezing. The beach umbrella storage and distribution was also expanded to give the employee more room and provide additional space for umbrella storage. Lastly, the supplies storage space, which was requested for storage of maintenance equipment and site furnishings, comprises 59 percent of the structure.

Another layout for the women's and men's shower structure was created. The objective for both shower structures was to increase shower capacity, provide additional toilets in the women's area, and provide more storage in the men's facility. The alternative design looked at options of staying within the existing footprint as well as expanding the structure.

2.2.3 Alternative Higher-End Exterior Aesthetic Design

The current Field 5 Bathhouse exterior aesthetics were primarily client-driven and focused on maintaining the existing exterior aesthetic. Except for the dining area, the exterior façade remained the red face brick. The new shower structures will also be built with an outer wythe of red face brick to match the existing building. Due to hurricanes and vandalism, the proposed Stantec design reduced the glass window area around the dining area by placing 2 feet of brick along the bottom and composite lap siding on the front under the gable. The exterior façade is illustrated in the rendering of the Revit building model shown in Figure 4.

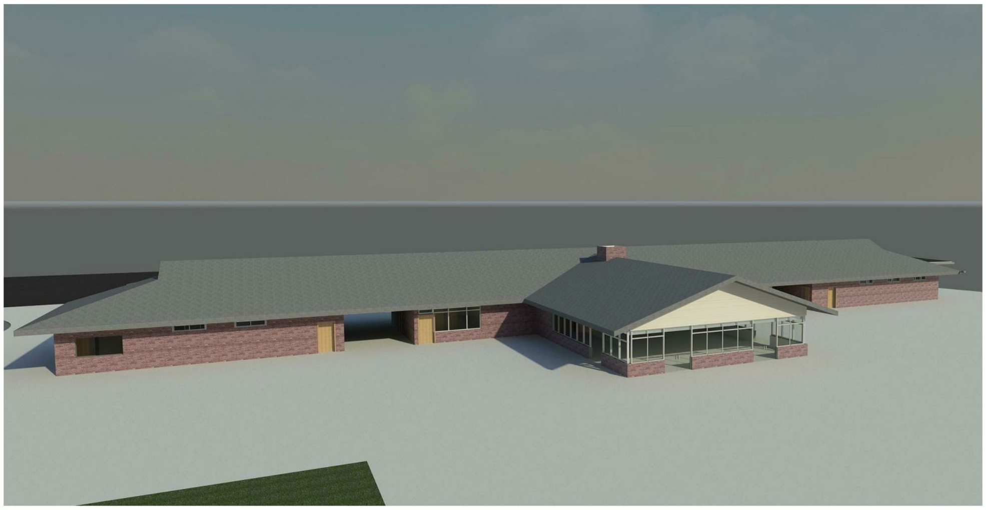


Figure 4 Proposed Exterior Aesthetic for Field 5 Bathhouse

The scope of this task was to develop a higher-end exterior aesthetic that would create more visual interest for Field 2 Bathhouse. Costs were considered when developing the alternative aesthetic design.

2.3 MQP Scope: Structural Design of Field 5 Bathhouse

The scope of the structural components of the Field 5 Bathhouse renovation includes replacement of masonry walls, installation of additional grade beams and piles, replacement of floor slabs, and extension of the roof structure.

2.3.1 Roof Framing

The scope of the Field 5 renovation includes expanding the roof structure. The proposed design extends the existing roof over the bathroom additions. The structure is similar to the existing roof framing plan, with 2"x14" roof framing spaced 16 inches on center. The roof has an overhang of 5 feet around the entire building. At the intersection of the load bearing walls and the roof is a horizontal I-beam, which supports the roof framing and the attic floor joists. The roof frame sits on the I-beam and cantilevers off 5 feet. The roof framing plan, including the slope, is shown in Figure 6. The majority of the roof has a pitch of 6:12. The east and west ends have a pitch of 4:12.

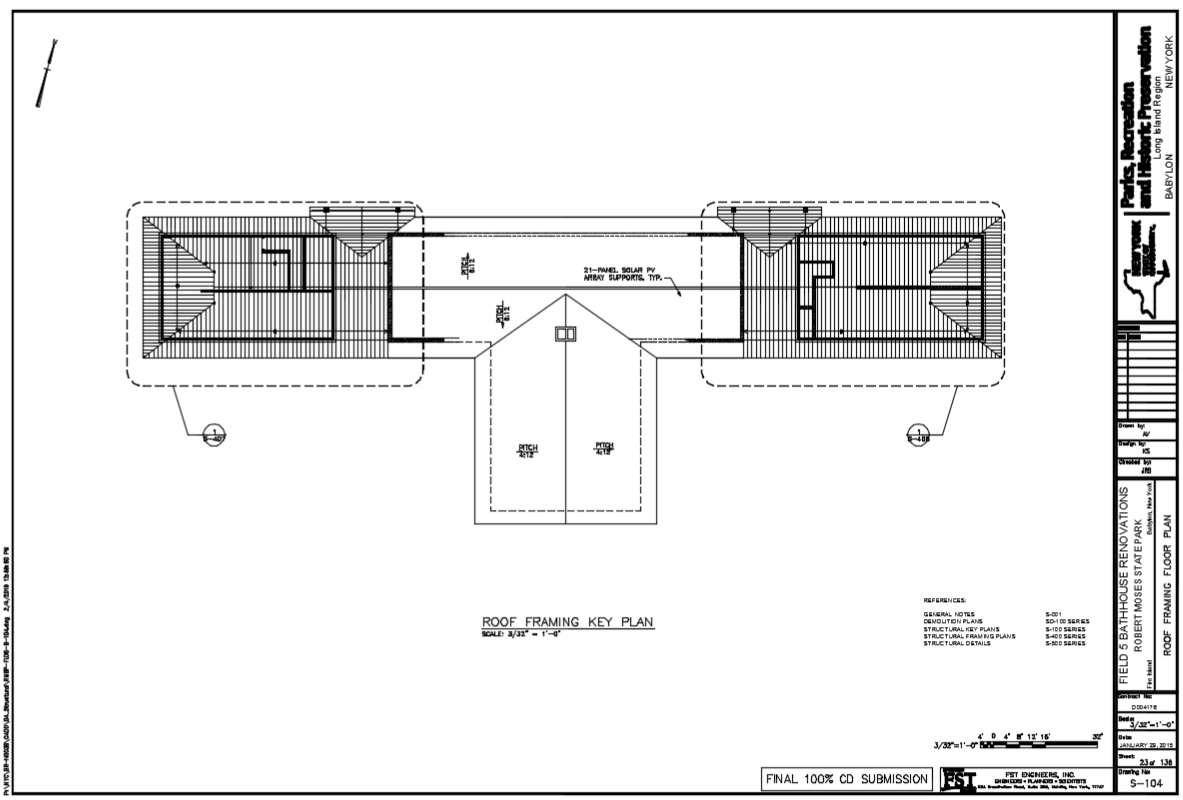


Figure 5 Roof framing plan Field 5 Bathhouse

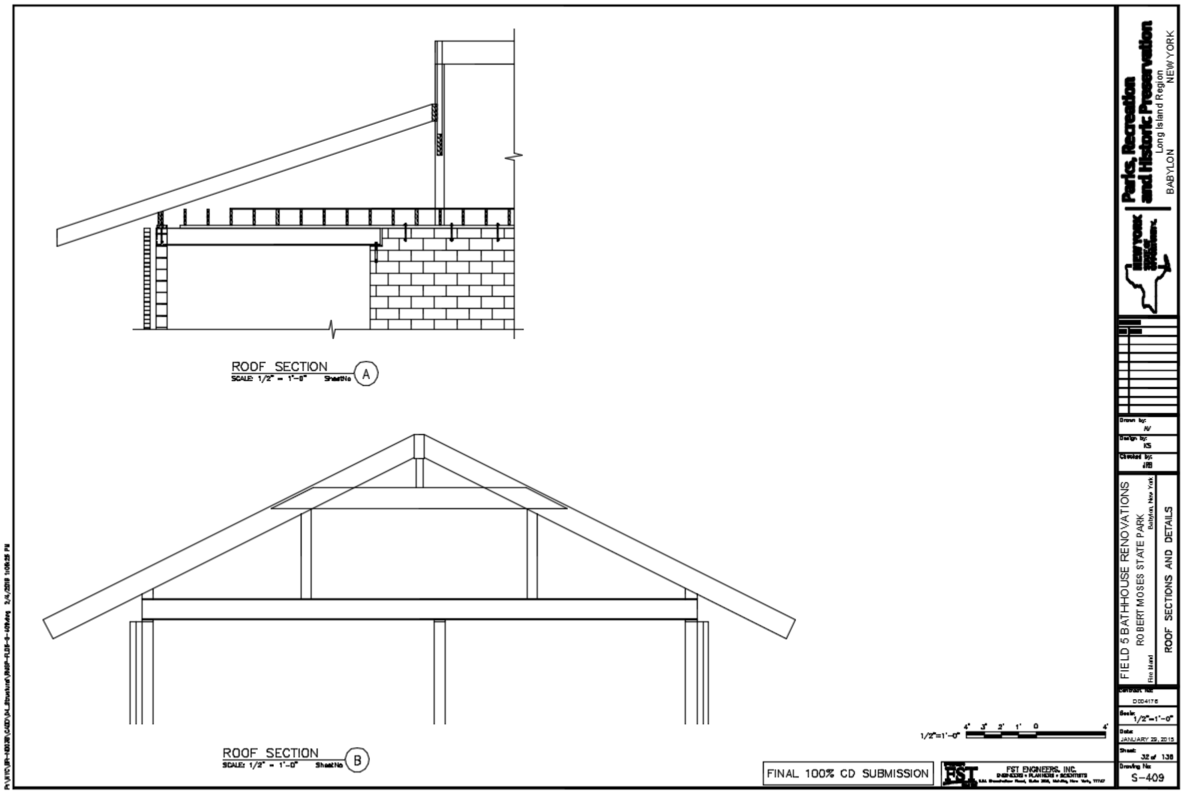


Figure 6 Roof section plan Field 5 Bathhouse

The section plan is seen in Figure 6. It shows the framing plan in the roof and a cross section of where the load-bearing wall meets the roof slope. The bracing of the roof framing are 2”x14” lumber. The attic is used for mechanical equipment, ductwork, and storage and must remain accessible for storage and equipment maintenance. The clearance in the attic needs to be 6 to 7 feet to accommodate employee access and storage. The attic is continuous throughout the entire north side of the building.

2.3.2 Slab

The floor slab design for the Field 5 Bathhouse consists of a 6-inch reinforced concrete slab. The slab is reinforced with #5 rebar. According to the *Basis of Design* provided by Stantec, the slab will taper into a thicker slab beneath the interior load bearing walls. The exterior load bearing walls sit directly on the grade beams. The slab abuts the exterior walls while overlapping the grade beam by 2-inches. A section of the slab, grade beam, and wall are shown in the following Figure 7, as well as in the appendix.

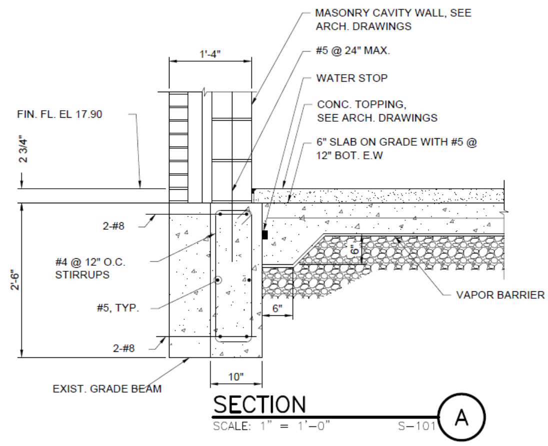


Figure 7 Slab, Grade Beam, and Wall Section

2.3.3 Grade Beams

The new construction of the bathroom facilities on either side of the Field 5 Bathhouse requires additional grade beams. The proposed grade beam section of the Appendix contains the foundation sections for Stantec's design. The dimensions of the beams are constrained by the width of the masonry walls that they will be supporting. Additionally, all of the beams have a depth of 30", with the exception of the new portico grade beams. The 30" depth matches the depth of the existing beams. The grade beams on the north and south sides of the building will abut next to the existing grade beams. The east and west side grade beams are new construction without existing beams. The 18" x 30" grade beams will be supported on new piles. Figure 8 shows the foundation plan.

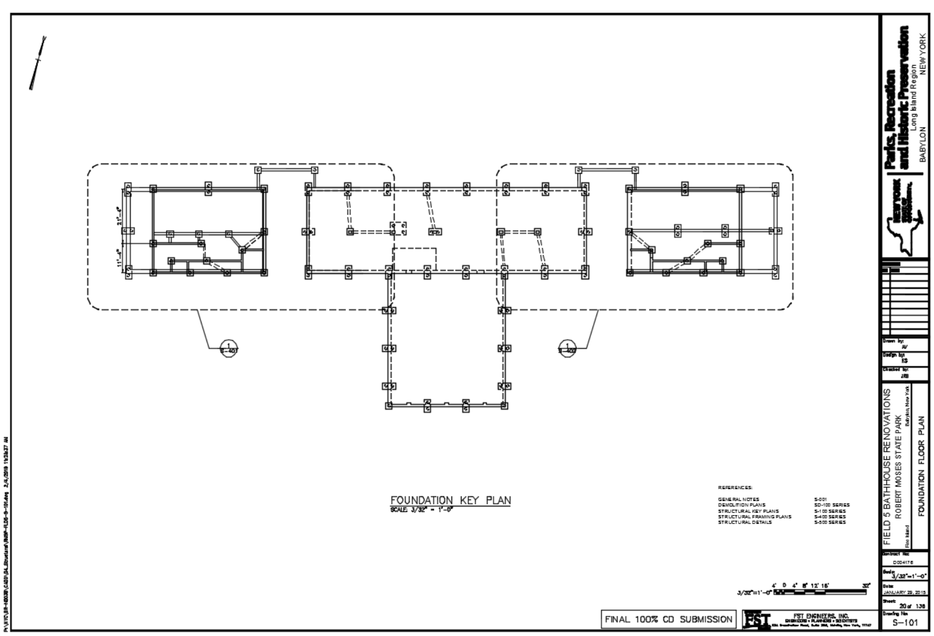


Figure 8 Foundation plan for Field 5 Bathhouse

An initial concern of the grade beam design is the arrangement of reinforcement. Reinforcing steel is defined in the tension zone, compression zone, and center of the beam. Typically, reinforcement is not included at the center axis of a beam.

2.3.4 Pile Cap

The pile cap designs for the field 5 Bathhouse consist of a single pile and a two-pile system. The two-pile system is a 5’ by 2.5’ cap containing reinforcement in both directions, with 6 #6 bars in the long direction and 3 #5 bars in the short direction. Figure 9 shows the pile cap details for Stantec’s proposed design. Additionally, the pile caps contain 4 #5 dowels that extend into the grade beam. The single pile section is the same as the two pile section, resulting in the same reinforcement arrangement but with shorter bar lengths.

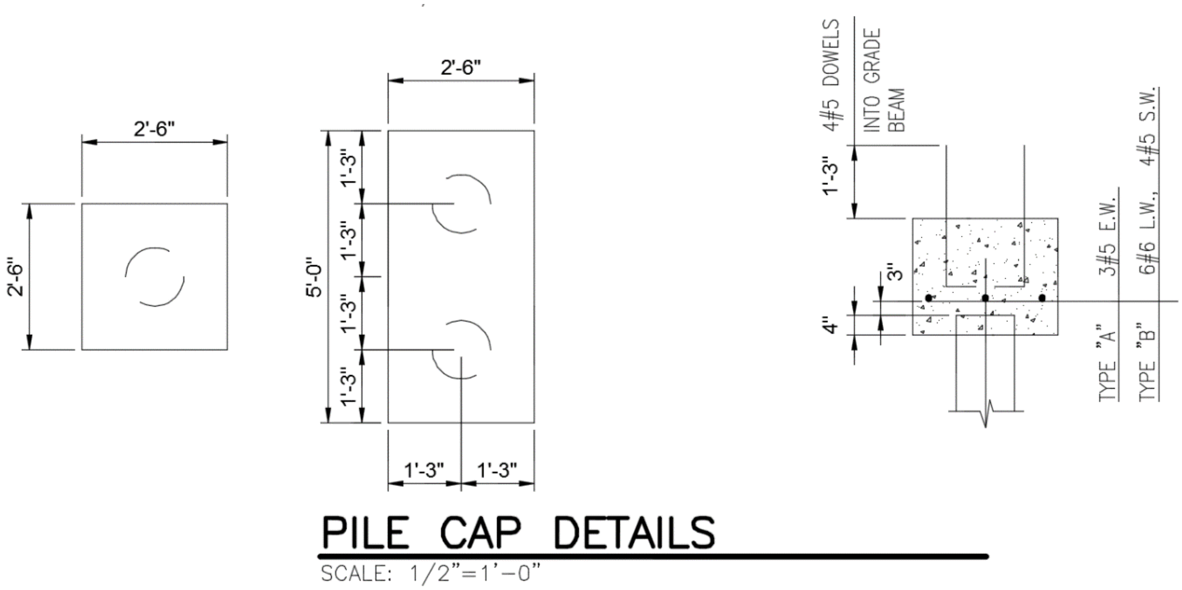


Figure 9 Stantec Pile Cap Details

2.3.5 Piles

The *Basis of Design* (Stantec, 2015) for the Field 5 Bathhouse states that wood piles will be used for the expanded foundation. The piles are required to have a bearing capacity of 20 tons with an 8-inch tip diameter. According to Stantec’s detail for the pile cap, the wood piles are 12” in diameter. The Proposed Pile Cap Design section of the Appendix shows the detail for the pile cap.

2.4 MQP Scope: Sister Bathhouse: Field 2 Bathhouse

Constructed approximately two years prior to Field 5 Bathhouse, Field 2 Bathhouse is located less than a mile to the west and is virtually identical to Field 5. OPR&HP is interested in renovating this bathhouse at some future time.

The initial project scope for Stantec began with renovation plans for Field 2 Bathhouse, but was changed to the Field 5 facility as OPR&HP determined they would rather have the main bathhouse renovated first. At the start of this project, Stantec had nearly finished the 100 percent design of the Field 5 Bathhouse. Thus, the architectural and structural design work in this MQP referenced the Field 5 Bathhouse to develop design recommendations for the future renovation of the Field 2 facility.

3 Results

While the scope of work for the Robert Moses State Park renovation project had distinct architectural and structural components, collaboration between the two disciplines was essential to the project. A building information model was developed in Revit to ensure the plans aligned with each other and the alternative designs did not create any conflicts between the systems. This was also used as a tool so the client could visualize the renovations and changes could be made before construction began, avoiding cost increases of changes during construction and potential delays. Field 5 Bathhouse can be seen below in Figure 10 through the renderings created in Revit.

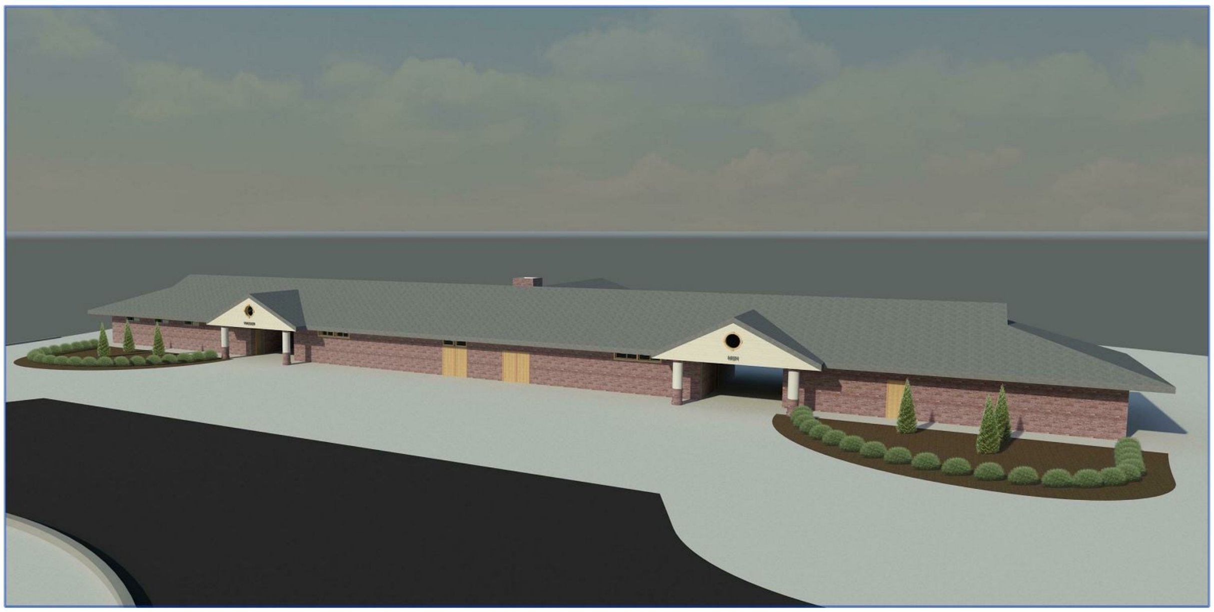


Figure 10 Field 5 Bathhouse Created in Revit

3.1 Architectural Results

This section includes recommendations for better energy efficiency, as well as alternative shower area layouts and aesthetics for the future renovation of the Field 2 Bathhouse. First, the designs are presented followed by the methods for creating them.

3.1.1 Energy Savings Analysis

This section covers the energy simulation study conducted for the Field 5 Bathhouse renovation. Given OPR&HP's energy-conservation goals, Stantec implemented key measures laid out in EO 111 to demonstrate energy savings in the proposed design. This requires that "*New Buildings and Existing Buildings Undergoing Substantial Renovations* achieve 20 percent and 10 percent improvements in energy reduction, respectively, relative to levels required by the New York State Energy Conservation and Construction Code (ECCNYS)" (Basis of Design, 2015). An energy model was completed using eQuest hourly simulation software to determine the performance savings of the proposed design and provide initial feedback on energy performance. The simulation results show energy and cost savings of approximately 15.8 percent over the baseline building. This performance meets the 10 percent prerequisite for sustainable renovations of existing buildings in New York as specified in EO 111.

The following sections outline the modeling assumptions including proposed design based on Stantec's 100 percent design documents for Field 5 Bathhouse and the corresponding baseline requirements as specified in ASHRAE 90.1 Appendix G. Any changes to the modeling assumptions outlined below will need to evaluated for their impact on performance savings.

3.1.1.1 Building Information

As described in the Background, the bathhouse is a two-story T-shaped building with detached locker/shower structures on the east and west sides for a total gross area of 18,230 square feet. The main bathhouse building has a concessions service counter and adjacent dining area. In addition, it has a beach shop, first aid office, area office, cash room, and public toilet facilities. The detached structure to the West is the men's shower & dressing area as well as storage areas, while the detached structure to the East is the women's shower & dressing area and public toilet facilities. The building is located in Climate Zone 4A. Figure 11 below shows a 3D rendering of the building modeled in the eQuest software.

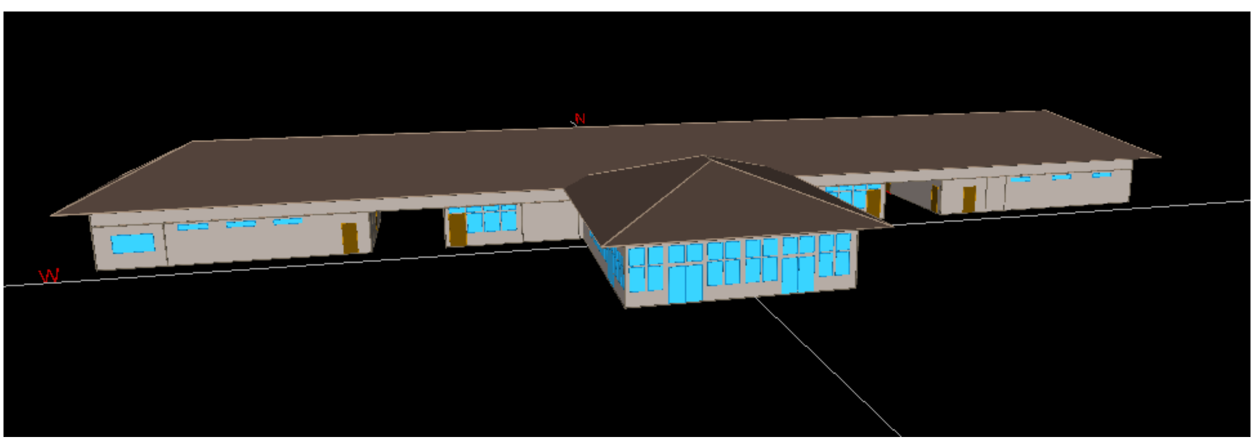


Figure 11 eQuest Rendering of Field 5 Bathhouse

3.1.1.2 Modeling Inputs

Table 3 below includes the modeling inputs for the building envelope, lighting, receptacle loads, HVAC, and domestic hot water in the baseline and Stantec's proposed design for the Field 5 Bathhouse.

Table 3 eQuest Modeling Inputs

Model Input Parameter	Unit	Baseline Design	Proposed Design
Building evelope			
Exterior wall construction (main building)	(U-factor)	Same as proposed	Two-wythes 4" face brick/2" structural clay tile (0.512)
Exterior wall construction (shower structures)	(U-factor)	Mass (0.090)	4" face brick/2" air gap/2" rigid insulation (R-10)/8" CMU/1" ceramic tile (0.070)
Roof construction	(U-factor)	Insulation Entirely Above Deck (0.048)	5/8" PVC synthetic soffit boards/6" (R-19) fiberglass blanket insulation/3/4" plywood roof sheating/ashphalt singles (0.046)
Slab-on-grade (unheated)	F-factor	0.73	0.73
Windows	U-factor	0.55	0.28
Windows	SHGC	0.4	0.26
Lighting			
Interior lighting power density	W/ft2	1.38 (avg)	0.43 (avg)
Lighting controls		None	Photocells and motion sensors
Receptacle Loads			
Receptacle Equipment	W/ft2	Same as proposed	3
Refrigeration Equipment	W/ft2	Same as proposed	4.3
Cooking	W/ft2	Same as proposed	12.1
HVAC			
Primary HVAC system type		PSZ-AC	AHU, V&H (2), PTAC
Exhaust fans	EER	9.3	10.2, 9.8, 11.4
Heating source		Furnance	Hot water loop with condensing boiler
Domestic Hot Water			
Equipment efficiency	% or EF	0.8 EF	0.9 EF

Since the existing systems at the Field 5 facility are not operating and have no salvage value, the baseline model was developed following the ASHRAE 90.1 Appendix G methodology for energy efficient design. The building envelope components including the wall, roof and fenestration were modeled to simulate the existing conditions. For the new construction of the detached shower structures, the U-factor for the walls and roof were assumed to be the common lightweight assembly values from ASHRAE 90.1 Appendix G Table 5.5-5. The fenestration was single glazed, aluminum-framed windows. The lighting was designed according to the minimum code lighting power densities for each space. The baseline consists of a packaged rooftop air conditioner with constant volume fan control, direct expansion cooling, and fossil fuel furnace heating. The hot water heating system was also modeled according to the standard with two hot water boilers with draft at 80 percent efficiency. The process of developing this model is detailed in 3.1.1.4 Energy Model Design Process.

Stantec's proposed design for the Field 5 Bathhouse was modeled according to the 100 percent design drawings. The walls and roof were created as detailed on the drawings, and the windows were changed to the specified double-pane, hurricane-resistant windows. The lighting was approximately 69 percent more efficient based on the fixtures chosen and included photocell sensors in the rooms with windows and occupancy sensors in every room. Light tubes were also placed in the men's and women's toilet rooms as a source of day lighting. The mechanical systems were designed to be cost-effective and energy efficient with high motor efficiency. Condensing boilers were also specified in the hot water system for increased efficiency. Custom schedules were developed for the bathhouse that reflects the actual building summer and limited off-season use, which differs from a typical building yearly operational schedule. These schedules are explained in futher detailed in section 3.1.1.5 Energy Modeling Design Process: Methodology.

3.1.1.3 Results

The simulation results displayed in Table 4 below give a performance energy savings of 15.8 percent and cost savings of 16.1 percent over the baseline building.

Table 4 Energy Simulation Results Between Baseline Building and Proposed Building

Fuel	Baseline Building Energy Use	Proposed Building Energy Use	Baseline Building Energy Cost	Proposed Building Energy Cost	Percent Energy/Cost Savings
Electricity (kWh)	126210	97074	$19,348	$14,881	23.1%/23.1%
Natural Gas (therms)	76859	65027	$190,610	$161,267	15.4%/15.4%
Total (MBTU)	8116.7	6834	$209,958	$176,148	15.8%/16.1%

Figure 12 below shows the graph of the relative contributions and various end uses to the energy and cost savings in terms of electricity.

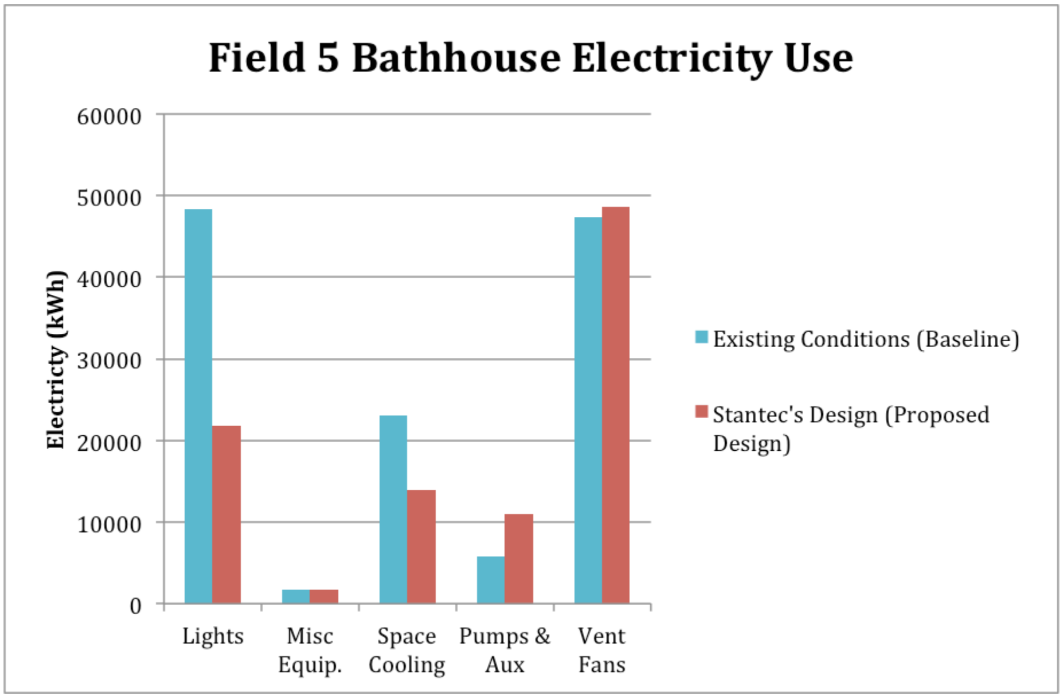


Figure 12 Graph of Electricity Use by End Use in Field 5 Bathhouse

As can be seen, there was a significant reduction in the lighting electricity consumption due to a better lighting plan with decreased lighting power density. Space cooling was also reduced through increased motor efficiencies of the mechanical equipment, in addition to improved wall and roof insulation and glazing. The miscellaneous equipment, or receptacle loads, were modeled the same for both the baseline and proposed design and therefore did not change. The electricity consumption for the "pumps & aux" and "vent fans" increased in the proposed design compared to the baseline model. This is because the baseline has a rooftop furnace, which uses mostly fans to transfer hot air from the rooftop unit to spaces. However, in the proposed design, the two boilers, hot water loop, and air handling unit (AHU) need pumps for water recirculation. As a result, extra electricity consumption is required to power this water recirculation. Overall, there was a 23.1 percent electricity use and cost savings.

Similarly, Figure 13 below shows the graph of the relative contributions and various end uses to the energy and cost savings in terms of natural gas.

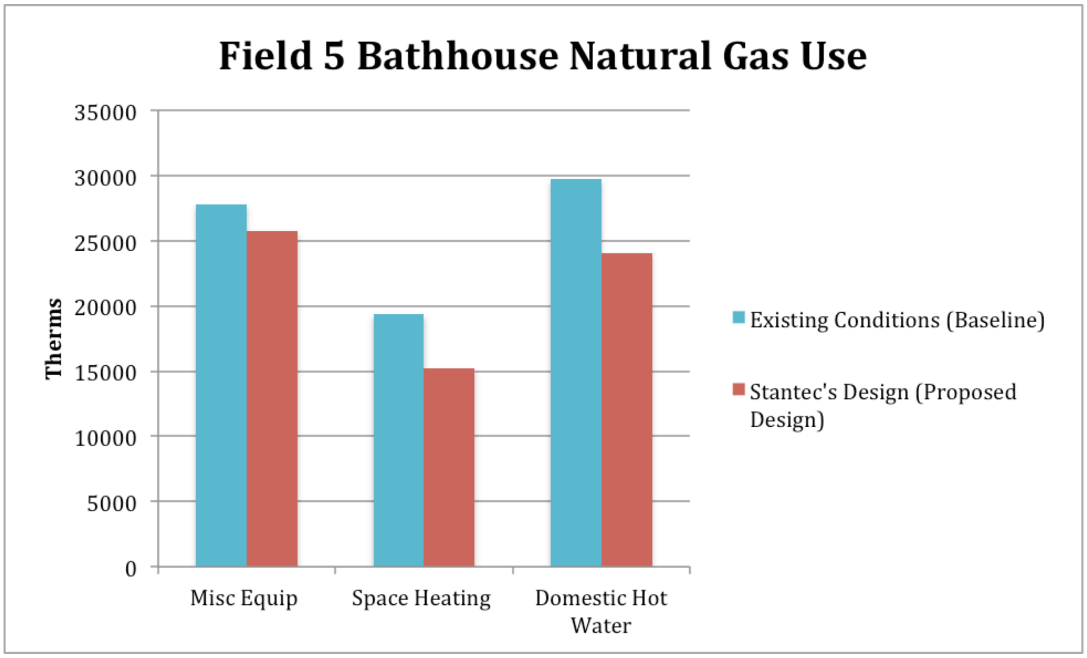


Figure 13 Graph of Natural Gas Use by End Use in Field 5 Bathhouse

The proposed design had savings in each category for natural gas explaining the overall greater percent cost savings (16.1%) than percent energy use savings (15.8%). The natural gas miscellaneous equipment load is due to the boilers; therefore, the load decreases between the baseline and proposed design since the boilers have greater efficiency. Space heating was reduced through improved glazing and wall and roof insulation, as well as increased motor efficiencies of the mechanical equipment. The domestic hot water system uses less natural gas because of the increase efficiency of the condensing boiler pumps, water recirculation, and low flow fixtures. Total, there was a 15.4 percent natural gas use and cost savings. More energy and cost savings would be realized if the bathhouse was operated year-round, where heating loads would be much larger.

3.1.1.4 Recommendations

Based on the results of the energy simulations, design recommendations were evaluated to find cost-effective alternatives to reduce the energy consumption of the Field 2 Bathhouse. Analysis was limited to the building envelope and increasing the use of solar panels due to project time constraints.

For Alternative One, it is suggested to increase the wall insulation for both the main bathhouse and detached shower structures from the existing R-10 insulation to R-13.3. This is the highest insulation that is recommended for Climate Zone 4A according to the *2012 IECC Commercial Scope and Envelope Requirements* (Energy, 2012). The improved U-factor for the wall assembly would be 0.057. Relative to the baseline, this improvement would reduce electricity use and cost by 8.5 percent and natural gas use and cost by 9.7 percent.

Alternative Two recommends increasing the roof insulation from R-19 to R-25, which is specified for cooler climate zones to reduce heat loss through the roof (Energy, 2012). The improved U-factor of the roof assembly would be 0.036. This design change would reduce electricity use and cost by 8.7 percent and natural gas use and cost by 10 percent relative to the baseline. Table 5 below shows the savings according to end use based on each alternative relative to the baseline.

Table 5 Energy Savings by End Use for Building Envelope Alternatives Relative to Baseline

	Lights	Misc Equip (Electricity)	Misc Equip (Natural Gas)	Space Heating (Natural Gas)	Space Cooling	Pumps & Aux	Vent Fans	Domestic Hot Water (Natural Gas)	Total Electricity (KWH)	Electricity Percent Reduction (%)	Total Natural Gas (THERM)	Natural Gas Percent Reduction (%)
Existing Conditions (Baseline)	48283	1745	27808	19351	23102	5784	47295	29701	126210		76859	
Improved Design - Wall Insulation	48283	1745	27808	14469	18227	5784	41452	27098	115491	8.5	69375	9.7
Improved Design - Ceiling Insulation	48283	1745	27808	14250	18359	5784	41112	27097	115284	8.7	69155	10.0

The two design recommendations were then simulated together as a set of improvements to the building envelope and evaluated for overall energy use and cost savings. The results were compared to both the baseline and Stantec's proposed design. Compared to the baseline building, the improved building envelope would result in a performance energy savings of 20.8 percent and a cost savings of 21.1 percent, summarized in Table 6 below.

Table 6 Energy Simulation Results Between Baseline Building and Improved Building

Fuel	Baseline Building Energy Use	Improved Building Energy Use	Baseline Building Energy Cost	Improved Building Energy Cost	Percent Energy/Cost Savings
Electricity (kWh)	126210	89149	$19,348	$13,667	29.4%/29.4%
Natural Gas (therms)	76859	61271	$190,610	$151,952	20.3%/20.3%
Total (MBTU)	8116.7	6431.3	$209,958	$165,619	20.8%/21.1%

Relative to Stantec's proposed building design, the improved building envelope would result in a performance energy savings of 5.9 percent and a cost savings of 6.0 percent, summarized in Table 7 below.

Table 7 Energy Simulation Results Between Proposed Building and Improved Building

Fuel	Proposed Building Energy Use	Improved Building Energy Use	Proposed Building Energy Cost	Improved Building Energy Cost	Percent Energy/Cost Savings
Electricity (kWh)	97074	89149	$14,881	$13,667	8.2%/8.2%
Natural Gas (therms)	65027	61271	$161,267	$151,952	5.8%/5.8%
Total (MBTU)	6834	6431.3	$176,148	$165,619	5.9%/6.0%

Alternative Three assessed decreasing the energy consumption of the Field 2 facility through increasing the use of on-site solar energy. Currently, both the Field 2 and Field 5 Bathhouse have two arrays of 21 solar panels providing some electricity to the building. Since peak season, and thus the largest energy consumption, is during the summer and the bathhouse is located at the beach, it is recommended to increase the number of solar panels across the entire ocean side roof and both sides of the roof on the dining area. Increasing the solar panel area as stated provided a potential cost savings of $14,421.85 per year according to PVWatts Calculator created by the National Renewable Energy Laboratory ("PVWatts Calculator,"). This is a 96.9 percent electricity cost reduction relative to Stantec's proposed design and significantly reduces peak demand charges. Calculations for the solar panel savings by area are shown in the Energy Modeling section of the Appendix.

3.1.1.5 Energy Model Design Process: Methodology

The energy models were created using eQUEST building analysis software, which contains DOE-2.2 as its simulation engine ("eQUEST," 2010). eQuest calculates the hour-by-hour building energy consumption over an entire year (8,760 hours) based on hourly weather data for the location of the site. The program requires a detailed description of the building being analyzed, which was input using the Design Development Wizard and edited in Detail Edit mode. The input data includes the building shell, structure, materials, and shades; building operations and scheduling; internal loads; HVAC equipment and performance; and utility rates. Throughout the energy modeling process, ASHRAE 90.1 Appendix G was used as the guideline for developing both the baseline and proposed model (Standard, 2007).

Geometry

The first step, and most important step, in creating the model was defining the geometry, which involved creating the building footprint, building zones, and building fenestrations. Since the results can vary greatly due to a small inaccuracy in area measurements, AutoCAD files of the floor plans were imported as an outline for tracing the custom building footprint. The zones were then established based on the usage of each room, pairing similar uses together. Figure 14 below shows the bathhouse floor plan on top and the eQUEST energy model zoning on bottom to see the similarities in zoning.

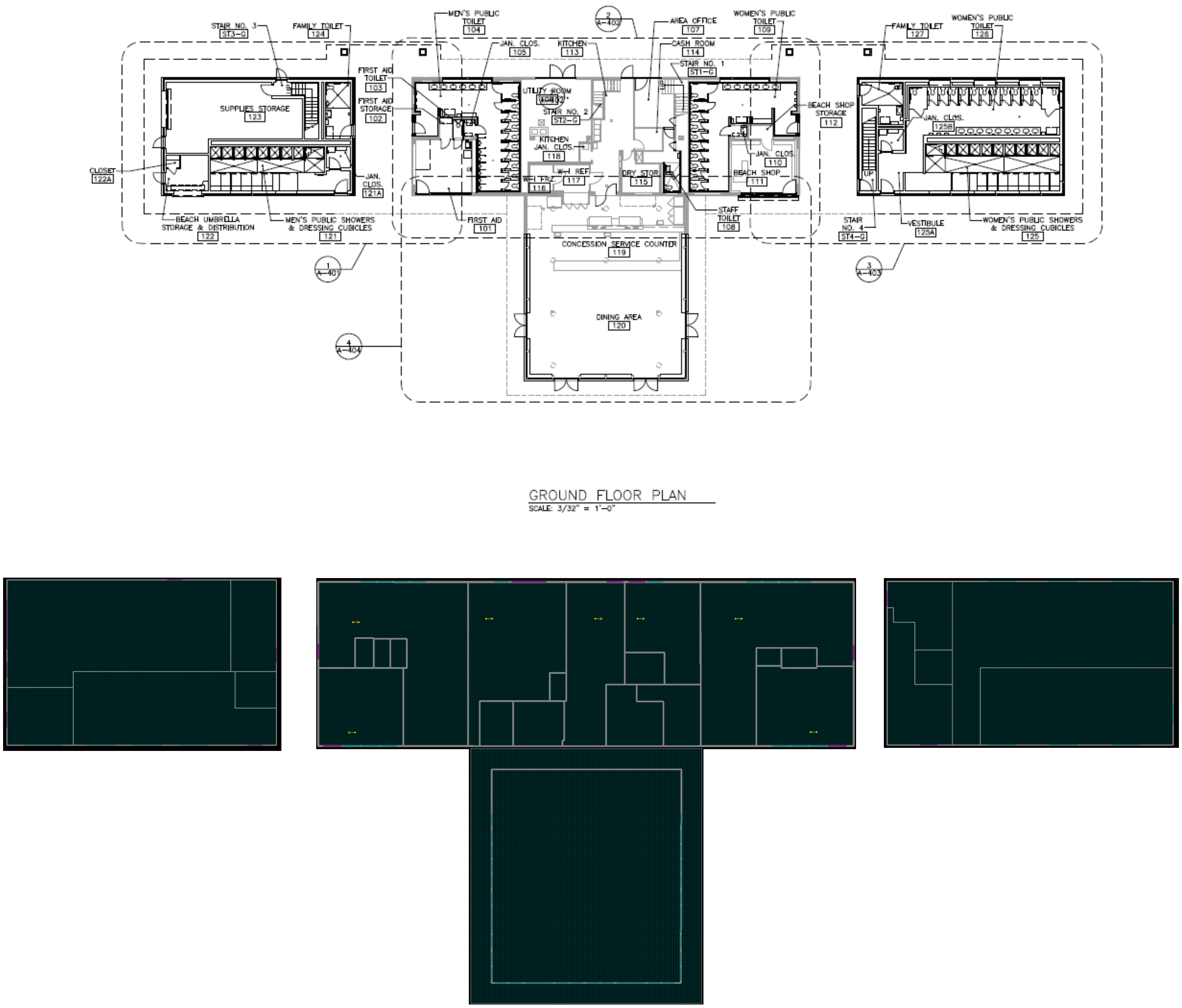


Figure 14 Field 5 Ground Floor Plan and Respective eQUEST Zones

According to the proposed design documents, the doors and windows were included in the model. The doors and windows on the shower structure additions in the baseline were less than 40% of the gross above-grade wall area; therefore, they were not changed to ribbon windows for the energy analysis. Second, the activity for each zone was identified according to the space type lighting classification in accordance with ASHRAE 90.1 Section 9.6.1 (Standard, 2007). The Energy Modeling section lists each zone and the associated activity.

Schedules:

The daily, weekly, and annual schedules for occupants, lighting, equipment, and thermostat set points were then defined based on building usage. Each year was broken into three time periods to model the peak summer period and lower winter use. Shutdown schedules were created for the detached shower structures, which are shutdown in the offseason. Custom schedules were developed because standard ASHRAE schedules did not fit the bathhouse usage. Building occupancy and lighting schedules were dependent on fraction "on" per hour of use with "0" being none or off and "1" being full occupancy or all lights on. These schedules as well as the others described here can all be found in the Energy Modeling section of the Appendix. Fan schedules reflected building occupancy and were on/off flag, meaning that the fans were on "1" when the building was occupied, off "0" but can cycle if there is a call for heating or cooling when unoccupied, and a flag of "-999" defines an optimum start period. For cooling, the thermostat set point was 80°F when the bathhouse was unoccupied and 75°F when it was occupied. The heating thermostat set point was 65°F for unoccupied and 70°F for occupied. The weekly schedules were then compiled to include the weekday, weekend and holiday, heating design day, and cooling design day. Lastly, the annual schedule comprised weekly schedules in the winter season (January 1st to April 30th and November 1st to December 31st) and the summer and spring swing season (May 1st to September 30th). A typical building yearly operational schedule would have consistent usage through all seasons of the year.

Building Envelope

The building envelope was modeled next. All components of the building envelope in the proposed design were modeled as shown on the drawings. The layers were input into the program and the U-factor adjusted, if necessary. Existing bathhouse walls in the baseline model were also added to the software in the same way. But for the new detached shower structure envelope in the baseline, the U-factor for the mass wall construction was taken from ASHRAE 90.1 Table 5.5-5 according to Appendix G Table G3.1(5) because the structures are additions (Standard, 2007).

Lighting

After, the lighting amount was specified for each zone based on space type lighting classifications. The baseline model lighting values were in accordance with ASHRAE 90.1 Table 9.6.1, while the proposed design model lighting wattage per square foot was calculated according to the lighting design. Table 14 in the Energy Modeling section lists the ASHRAE lighting standards and the actual lighting values for each zone.

Zoning

Since the thermal blocks were not defined on HVAC design drawings, thermal blocks were created based on similar internal load densities, occupancy, lighting, and thermal and space temperature schedules. The five thermal blocks for both the baseline and proposed energy model are illustrated in Figure 15 below and include (1) the men's public shower area, (2) the main bathhouse, (3) the women's public shower area, (4) the dining area, (5) the attic. The public shower areas are detached structures operating only during peak summer times, and therefore were assigned as individual thermal blocks. The dining area is a 2,390 square foot room with three walls of almost entirely exterior glazing, no attic space above it, and a concessions area with some cooking and refrigerating equipment. This made it a unique area and thermal space. The attic is unconditioned, as it is only occasionally entered for maintenance, and therefore was defined as its own thermal space. The remaining area of the bathhouse was grouped together as a thermal block because the usage did not vary significantly and the schedules were the same.

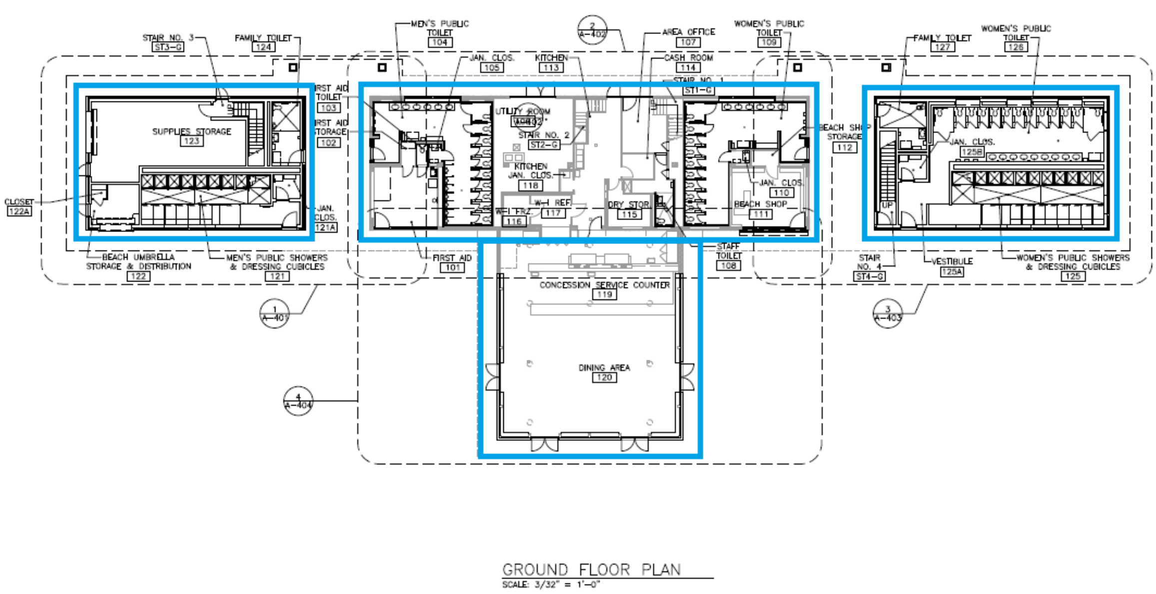


Figure 15 Bathhouse Thermal Blocks in eQUEST Energy Model

HVAC

The HVAC systems were then specified and assigned to each thermal block. The baseline building design HVAC system depended on the building type and fuel type. Based on these requirements, ASHRAE 90.1 Section G3.1 described the system and performance specifications (Standard, 2007). ASHRAE 90.1 defines the most economical systems for the building size and use. For the bathhouse, which is nonresidential less than 3 floors and fossil fuel type, the HVAC system was System 3, a packaged rooftop air conditioner (PSZ-AC). This baseline system included constant volume fan control, direct expansion cooling, and fossil fuel furnace heating. Additional requirements of the baseline HVAC systems are continuous operation of supply and return fans, minimum outside air equivalent to proposed design, and an outdoor economizer with a high-limit shutoff of 70°F. The baseline systems were sized according to the system fan power equation in ASHRAE 90.1 G3.1.2.9 using the flow of the proposed mechanical equipment, fan motor efficiency assuming 1800 rpm listed in Table 10.8, and the energy efficiency ratio (EER) from Table 6.8.1A-F (Standard, 2007). The equipment capacity was oversized by 15% for cooling and 25% for heating, and the unmet load hours were checked to ensure that it did not exceed 300 of the 8760 hours simulated.

The proposed design model HVAC system reflected the actual system type using the actual component capacities and efficiencies. The mechanical systems for the bathhouse renovation include an air-handling unit (AHU) that serves the main bathhouse, two heating and ventilation units (HV) that serve the public shower areas, and a packaged terminal air conditioning unit (PTAC) in the first aid room that conditions that zone. These systems were each paired with the closest replica in the eQUEST software (a heating and ventilation system for the AHU and HVs and a packaged terminal air conditioner for the PTAC) and modified to reflect the actual system. For each system, the kW per flow, static pressure, efficiency, supply flow, and minimum outside air varied depending on the thermal zone being conditioned. On the zone level, the supply air and exhaust air from the system to the different zones varied based on the size and usage of the zone and needed to be input for each area into the software separately.

Hot Water

The service hot water system was afterwards modeled. The baseline followed the guidelines established in ASHRAE 90.1 Appendix G and was made up of two hot water boilers with draft at 80 percent efficiency. The proposed design model reflected the actual system with equipment capacities and efficiencies. In the service hot water system are two condensing boilers at 90 percent efficiency, a primary hot water loop, and secondary hot water loop.

Plug Loads

Other receptacle and process loads, such as those for refrigeration and cooking equipment, were estimated based on the space type and assumed to be identical in the baseline building and proposed design model. These miscellaneous loads in the facility are specified above in Table X.

Assumptions

Since the energy model was used to simulate the energy consumption of the building retrofit, not all information was known about the existing conditions. Therefore, in order to completely design and simulate the building for energy efficiency some reasonable engineering assumptions or estimations needed to be made. The weather file was taken from New York, New York, the closest large city, because an existing file with decades of weather information did not exist for Long Island, New York. Second, the activities in each zone were matched to the closest activity described in ASHRAE 90.1. Third, the schedules were assumed based on expected occupancy, lighting, and equipment use for the facility. The utility rates were assumed to be flat rates according to the New York commercial 2015 rates, which were predicted to not affect the results substantially. Finally, the radiant hot water system was not modeled, and therefore the hot water loop was assumed to be the source of heating at the zone level.

3.1.2 Alternative Layout for Women's and Men's Public Shower Structures

Since the main bathhouse involved major renovations and the public showers are new structures, the number of fixtures in the bathhouse needed to be determined according to the most recent code. According to the *2010 Plumbing Code of New York State*, the number of fixtures is based on the number of occupants according to the Building Code of New York State (Administration, 2010). Following these codes, the building with 282 occupants and similarity to stadiums, amusement parks, bleachers and grandstands for outdoor sporting events and activities (A-5) occupancy required 2 water closets for men, 4 water closets for women, 1 lavatory for men, and 1 lavatory for women. However, this number of fixtures is grossly inadequate for the usage of the bathhouse.

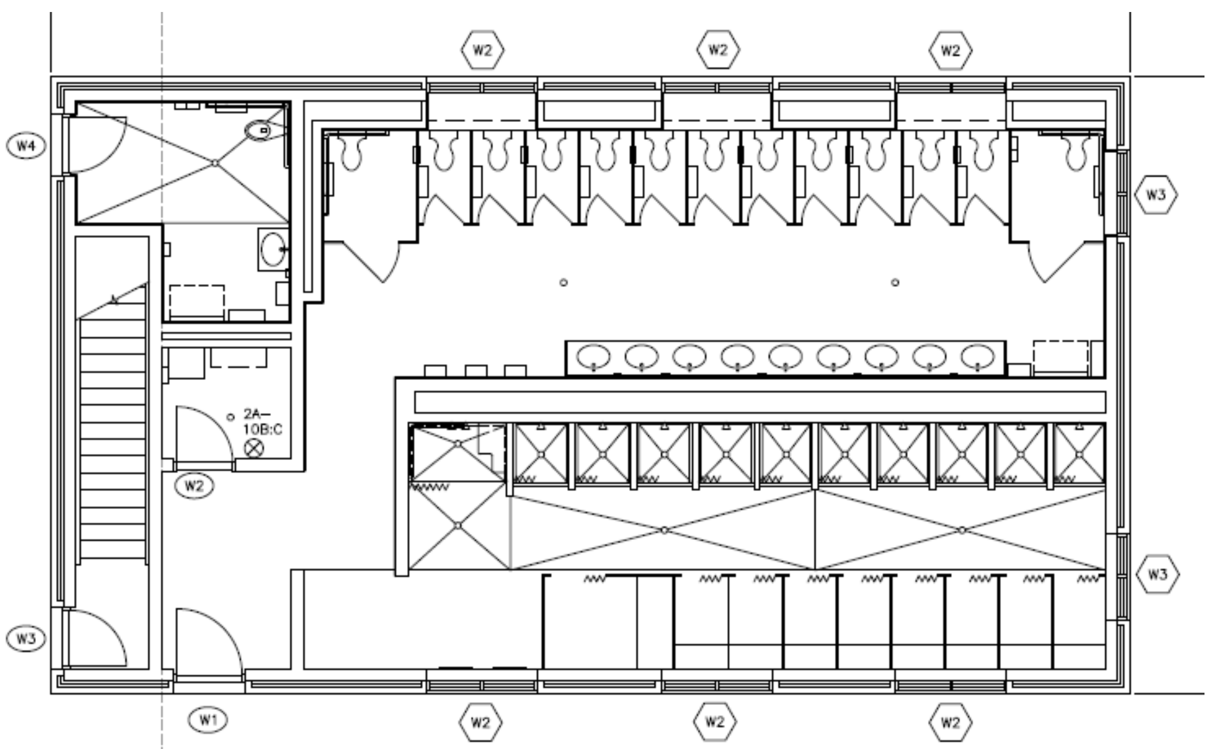
To better account for the usage, the occupant load was based on three occupants per parking space, which conforms to the Suffolk County Department of Health. The occupant load would be 8,892 based on the 2,964 parking spaces at Field 2 Bathhouse. Using the *2010 Plumbing Code of New York*

State and again assuming A-5 occupancy, the number of fixtures required was 45 water closets for men of which half could be urinals, 88 water closets for women, 23 lavatories for men, and 30 lavatories for women (Administration, 2010). This significant increase in fixture count would overwork the existing septage system and require more expansive additions to house the fixtures. If the bathhouse was completely new construction, it would be required to install this many fixtures; however, for the existing building with the same use classifications, the aim is to improve upon existing conditions.

Therefore, the purpose was to maximize the number of fixtures within the existing constraints, such as the septage system capacity and building area. The design and installation shall still be code compliant according to the *2010 Plumbing Code of New York State* and the ICC/ANSI A117.1 *2003 American National Standard for Accessible and Usable Buildings and Facilities* (Council, 2003).

3.1.2.1 Women's Public Shower Structures

In the alternative layout for the women's public shower structure, shown in Figure 16, the number of toilets was increased by 2 to a total of 15 toilets, and the number of lavatories and hand dryers was increased by 1 to a total of 10 and 4, respectively. The dimensions of the structure are 58'-4" by 33'-4", which is 14 feet wider than the existing structure to accommodate the required stairs and allow for the addition of the family bathroom.



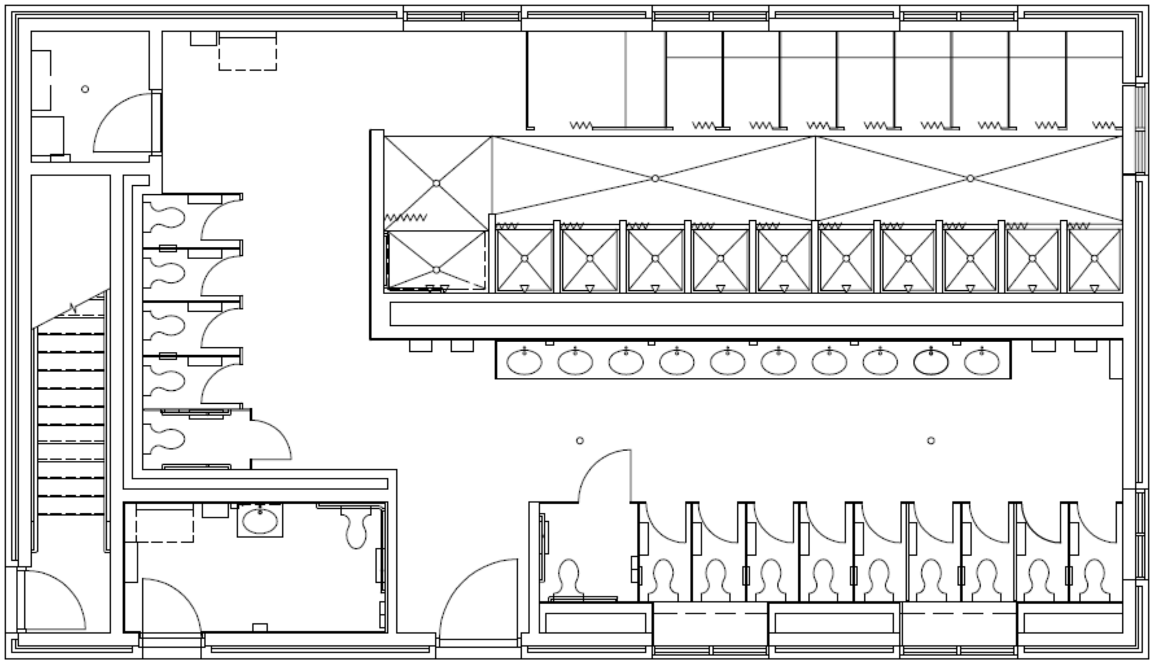


Figure 16 Stantec Proposed Design for the Women's Public Shower Area (top) and Alternative Layout of Women's Public Shower Area (bottom)

Extending the length of the structure 14 feet to the east does not interfere with the pedestrian walkway from the beach; however, increasing the width of the structure would be a significant added cost because it would require an additional grade beam and pile caps. Therefore, the width (33'-4") was the limiting dimension for the design and was considered first for the layout of the fixtures.

Table 8 lists each fixture, and the minimum, optimum, and actual dimensions based on the *Architectural Graphics Standards* (Architects, 1994). Since the shower structure is a public facility, the area needs to meet ADA accessibility requirements specified in the ICC/ANSI A117.1 *2003 American National Standard Accessible and Usable Buildings and Facilities* (Council, 2003). These include at least a 5' diameter circle turning space, a minimum clear distance between fixtures of 4'-10", at least one wheelchair accessible toilet compartment, and one ambulatory toilet compartment if there are more than 6 fixtures.

Table 8 Dimensions of Fixtures in Public Shower Facilities

Fixture	Minimum Dimensions	Optimum Dimensions	Actual Dimensions
Shower Stalls	2'-8" x 2'-10"	3'-6" x 3'-6"	2'-10" x 3'-8"
Wheelchair Accessible Roll-in Shower Stall	5'-0" x 2'-6"	-	5'-4" x 4'-0"
Dressing Cubicles/Compartments	3'-0" x 3'-6"	3'-6" x 4'-0"	2'-10" x 5'-0"
Wheelchair Accessible Dressing Cubicle/Compartment	6'-4" x 5'-0"	-	7'-0" x 5'-0"
Water Closet	2'-3" x 3'-9"	3'-4" x 5'-7"	2'-8" x 5'-0"
Wheelchair Accessible Water Closet	4'-8" x 5'-0"	5'-6" x 5'-6"	5'-0" x 5'-0"
Ambulatory Water Closet	3'-0" x 5'-0"	4'-0" x 5'-6"	3'-0" x 5'-0"
Lavatory	1'-4" x 1'-4"	2'-4" x 1'-9"	2'-0" x 1'-9"

Based on the specified dimensions for each fixture, the required clear space, and the width constraint, the maximum number of fixtures that fit within the width was four, and included a shower stall, dressing compartment, toilet stall, and sink. These fixtures were then placed alongside each other lengthwise to reduce the required number of plumbing walls and the chance of pipes freezing. The straight stairs remained the same because of their comparatively limited use of space. The janitor closet was sized to fit in the additional space next to the stairs, but was set large enough for both the radiant floor heating equipment and cleaning supplies. The family toilet room was placed next. Moving the door on the family toilet room from the front to the side, as shown in Figure 17, utilized the turning radius for both the entrance and hand washing/drying.

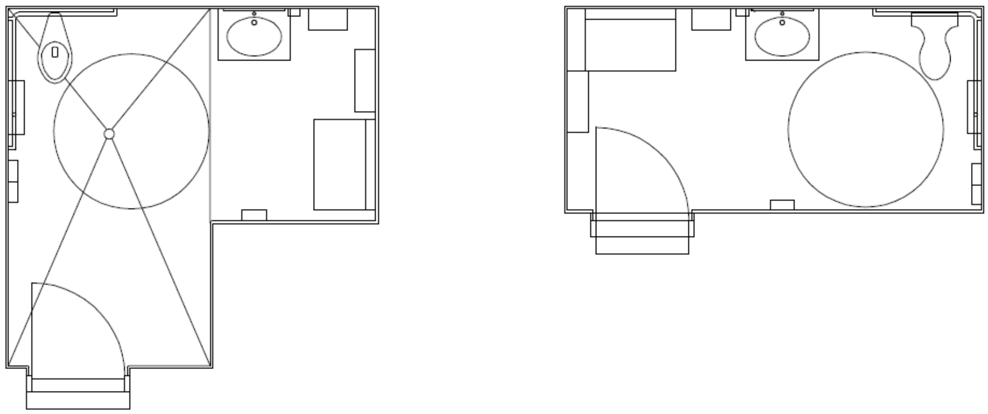


Figure 17 Family Restroom Design with Wheelchair Turning Radius

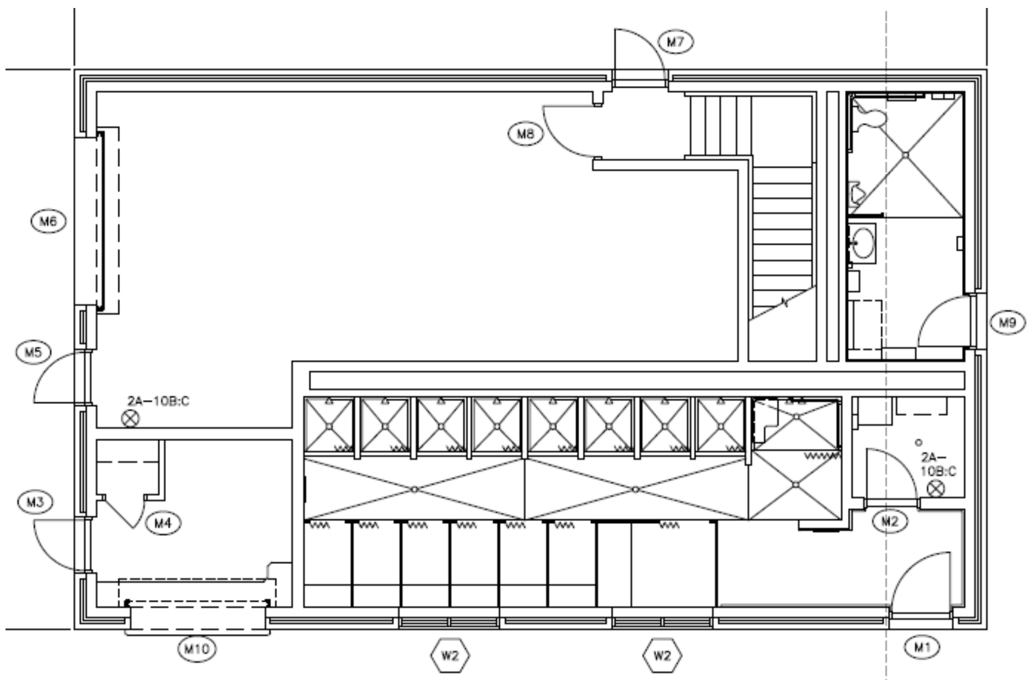
This made the restroom more compact, which provided space for a few more fixtures. Once the minimum number of fixtures was placed and additional space requirements met, the minimum accessibility clearances were marked to determine areas where more fixtures could be added. More toilets were then added in the open space, as well as another sink and hand dryer.

In addition to the added fixture count, this design has a few benefits in particular. The toilets are closer to the beach side, with the wheelchair accessible stall and ambulatory stall located close to the entrance. The entrance door was placed so visitors only wanting to use the showers and/or dressing cubicles do not need to pass through the entire bathroom to reach them. For more privacy, the diaper hanging table was placed in the corner. The lavatories and hand dryers are also close to the entrance for convenience and better flow of people. Additionally, the family toilet room was placed on the beachside to be closer to the beach and dining area.

Other alternatives considered had the main entrance on the side, but this was not as convenient as visitors were typically coming from the beach and would have to travel a longer distance once in the facility. Another option had the showers closer to the beach, which allowed more room for lines to form for the bathrooms, but required more entrance space for shower privacy. Finally, plans were created with the family toilet room next to the stairs in place of the janitor closet. However, the sizing of the janitor closet best fit the space, and it was more convenient to place the family toilet closer to the beach and dining area.

3.1.2.2 Men's Public Shower Structures

The proposed design for the men's public shower area has a larger storage area by 2.5 percent. This was achieved by changing the dividers between the showers to 1 ½ inch phenolic partitions used in the current facility, rather than the 4-inch brick separators proposed by Stantec, so the shower and dressing area could fit along the shorter wall of the structure. While changing the stairs to a straight run to eliminate the need for a mid-stair landing on the ground floor was considered, this did not leave enough entry room into the shower and dressing area. To leave the most open area for the supplies storage area, the family restroom was placed on the perimeter of the building, and the janitor's closet fit between the stairs and entry to the shower and dressing area. Figure 18 shows Stantec's proposed design for the men's public shower structure, as well as the alternative design for the area below.



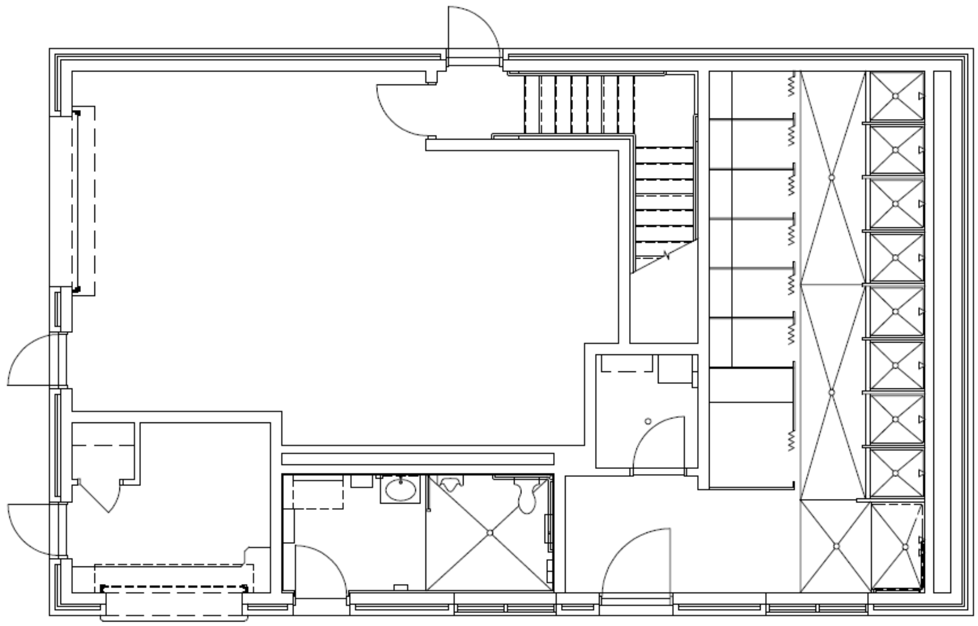


Figure 18 Stantec Proposed Layout of Men's Public Shower Area (top) and Alternative Layout of Men's Public Shower Area (bottom)

When redesigning the men's facility, there were multiple constraints that needed to be considered. First, the beach umbrella distribution and storage had to be located on the beachside to publicize the rental from the shore and make it easier for visitors to bring the umbrellas to their beach spot. Second, it was requested that the supplies storage area had a roll up equipment door for moving equipment in and out of the building. For aesthetics and movement of equipment, this door was located on the west side. Third, the janitor's closet needed to open into the shower and dressing area for easier upkeep. Finally, the top of the stairs had to be towards the center of the attic since it is the highest point of clearance due to the truss roof structure.

3.1.3 Alternative Higher-End Exterior Aesthetic Design

The proposed exterior aesthetic design was inspired by the renovations completed by Samyn-D'Elia Architects at Hampton Beach State Park in New Hampshire. Similar to the Robert Moses State Park facilities, these bathhouses were upgraded to provide restrooms, showers, and shaded areas for visitors. Figure 19 below illustrate the coastal-theme architecture style of the buildings with the shingles and picture windows replicated in the design for the Field 2 Bathhouse. These bathhouses were chosen as a model for the facilities in Robert Moses State Park because of their modern look and energy efficient features, both important to OPR&HP.

Figure 19 Hampton Beach State Park Bathhouses

Below in Figure 20 and Figure 21 is an elevation and rendering of the alternative exterior aesthetic design. The main façade is covered in light grey horizontal lap siding with approximately 2 feet red face brick around the bottom and 2 feet of blue shingles across the top. The architectural trim around the windows, between the brick, siding and shingles, and at the edges of the walls is 4-inch white wood trim. Except for the bottom row of fixed windows along the dining area, two vertical mullions and one horizontal mullion were added to the windows for aesthetic appeal. All the doors have white wood frames, but the size of the glass lites in the doors vary. Each portico and under the gable of the dining area has an architectural circle top window for visual interest. The roof is also designed with light grey asphalt singles with copper flashing for better energy efficiency and to delay the onset of a "dirtier" look. For a higher-end look and to reduce the potential for storm damage, red brick matching the existing brick was placed under the windows along the dining area and on the columns of the porticos. Having brick along the bottom perimeter helps incorporate the modern architectural features while maintaining the traditional finishes of the other bathhouses.

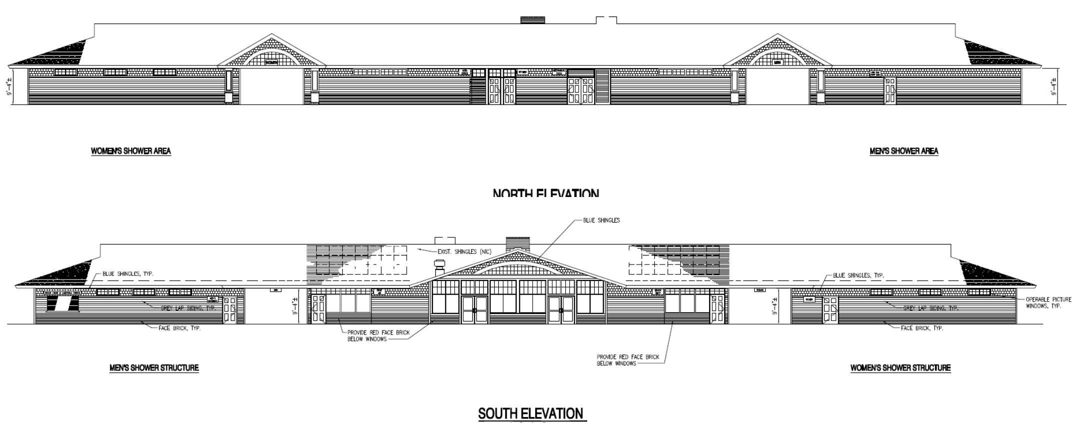


Figure 20 Field 5 Bathhouse Exterior Elevations with Higher-End Exterior Aesthetics

Figure 21 Rendering of Higher-End Exterior Aesthetics of Field 5 Bathhouse

Two other alternatives were considered before further pursuing the coastal-theme architectural aesthetic.

The first was based on the design of Field 3 Bathhouse, shown in Figure 22. This bathhouse has blue engineered wood siding with white wood trim and casement windows. Since the Field 2 Bathhouse is located on the other side of the Field 3 facility, the idea was to match architectural design. This option was not chosen because of the simplicity and out dated look. However, if OPR&HP wishes for its facilities to be similar, some of these design features can be incorporated into the Field 2 Bathhouse.

Figure 22 Field 3 Bathhouse, Robert Moses Park, Long Island, New York

The second alternative mirrored a restaurant typical of the architecture on Fire Island. "Surfs & Out" in Figure 23 is constructed with the same materials as Field 3 Bathhouse, but has reverse coloring with white siding and blue trim. The brighter blue around the fixed windows and full glass doors attracts customers inside, which would transfer well to the dining area of the bathhouse. Compared to the other bathhouses, this style did not blend well, and therefore was not further pursued.

Figure 23 Surfs & Out Restaurant, Fire Island, Long Island, New York

3.2 Structural Results

The structural results of the Robert Moses State Park project are broken down by component. The structural designs are based on the Field 5 bathhouse, but are compatible with the Field 2 facility due to the similarities in the structures. Each component begins with the alternative design(s), followed by design considerations, cost comparison, and the design procedures.

3.2.1 Roof Structure Design

The first alternative for the roof structure consists of a series of cambered trusses. The truss dimensions match the dimensions of the existing roofline, which allows the integration of the roof addition with the existing roof. The timber sizes for each of the members are shown in the figure below.

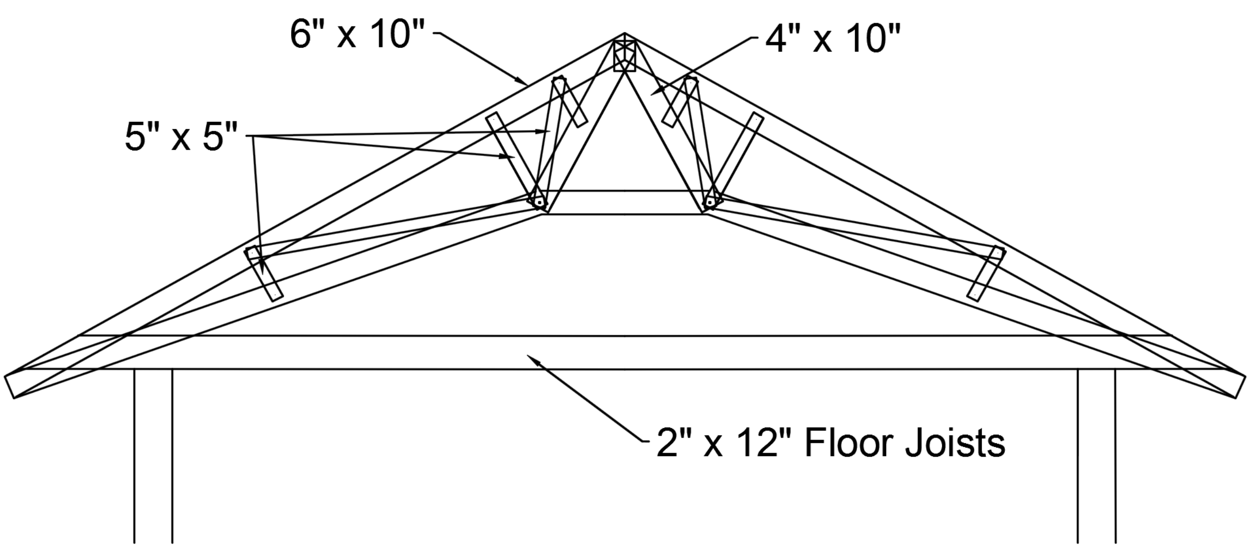


Figure 24 Cambered truss design

The main chord sizes are 6" x 10" Southern Pine. The trusses are spaced eight feet on center with purlins spaced four feet on center. This spacing allows for both the structure to support the roof and applicable loads, as well as conform to the standard 48" by 96" plywood sheathing.

The second alternative design for the roof structure utilizes glued laminated timber. This engineered lumber design uses 1 ¾" x 11 ¼" 3 ply glued laminated lumber for the rafters and 3 ½" x 5 ½" glued laminated timber for the ridge posts. The Framing matches the pitch of the proposed framing plan (6:12 on the north and south, 4:12 on east and west). The engineered lumber is spaced 24" on center.

The connections for the framing follow the BCNYS 2304.9.1 (Building Code New York State, 2010) requirements for connections and fasteners.

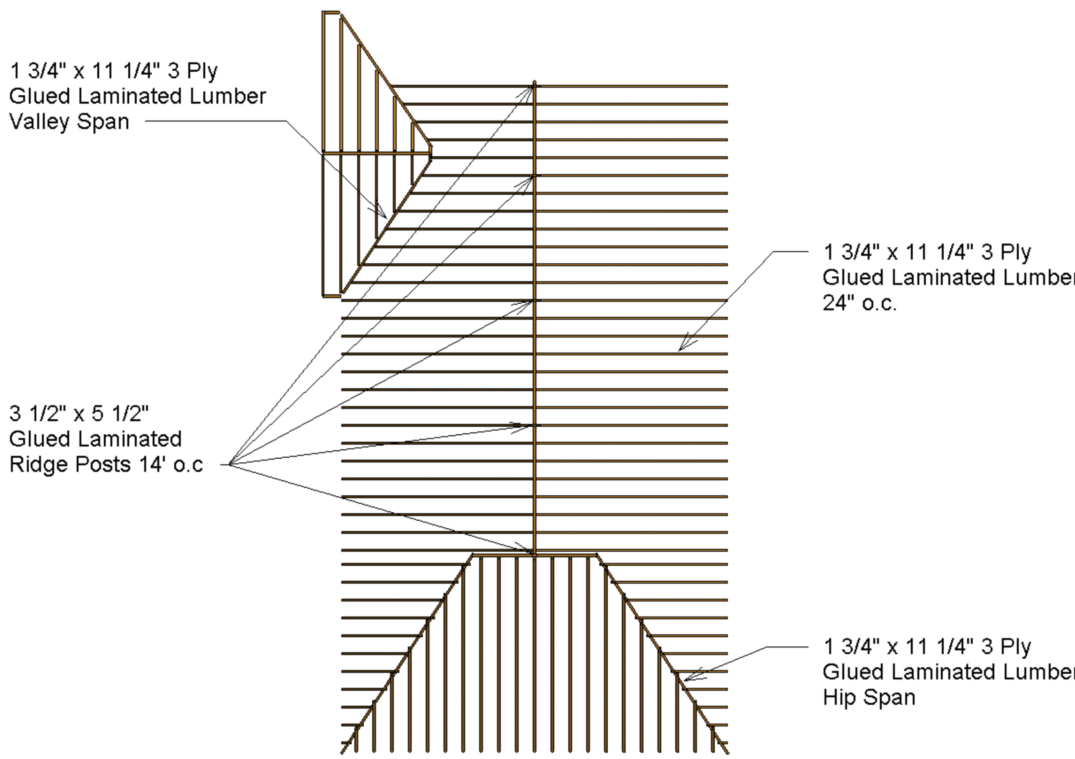


Figure 25 Glued Laminated Framing Plan (partial)

Design Process

The roof design was completing using Autodesk Robot Structural Analysis software (Autodesk, 2016). The proposed design was modeled in the software and analyzed to develop a baseline analytical model. The Robot Structural Analysis section of the Appendix explains the input process in detail, including the Excel procedure to increase efficiency. Alternate roof designs were developed based on design constraints and design goals.

Table 9 Roof design constraints

Goal	Design Constraint	Reference
Increase attic clearance	Min. clear height 6.5 feet	Stantec *Basis of Design*
Maintain existing geometry	5 ft overhang	Stantec 100% Design Drawings
Maintain existing geometry	Consistent roof elevation/height	Stantec 100% Design Drawings
Maintain existing geometry	Match existing roof slopes	Stantec 100% Design Drawings

Constraints included requirements such as a minimum height clearance in the attic. The design goals were to reduce cost of the roof structure while meeting or exceeding the code requirements for the building load.

The Robot Structural Analysis (Autodesk, 2016) software factored geometry, materials, boundary conditions, and load cases to analyze the structure. The initial alternate designs were developed based on assumptions by the user. The section sizes and materials were assumed based on the proposed design (2" x 14" beams). The structural model analyzes the building based on these assumptions, and shows the results of individual members as to whether or not they conform to the NDS specifications for wood design (ANSI/AWC, 2015). The process was iterative. If a given member size failed, a new member size was chosen. The timber design of the software allowed all members of the same group to be changed. The groups were defined when entering the members into the model. The top chord was entered as a different group than the bottom chord, and each of the other members was entered as a separate group. After each analysis iteration, the user chose new member sizes until the results of the software yielded passing members. For constructability reasons, effort was made to construct the roof structure using uniform dimension lumber whenever possible.

The glued laminated roof structure was designed using NDS 2015 (ANSI/AWC, 2015) and the manufacturer's design guide by TrusJoist™ (TrusJoist, 2014). From the manufacturer's guide, the rafter depth was obtained by referencing the *Rafter Span and Heel Connection Tables*. The rafter depth was determined by choosing a desired spacing and scanning down the appropriate column for the expected load, while cross-referencing with the span length. The hip members and valley beams were determined using the same process as the rafters, but with their respective tables. In order to improve constructability, similar dimensions were used for the hip and valley members. The nail quantity is also listed in the table; however, the BCNYS 2304.9.1(Building Code New York State, 2010) must be referenced for all connections.

3.2.2 Slab Design

One alternative design to the proposed 6" concrete slab is to simply increase its thickness. Through analysis of the proposed slab design, it was determined that the ACI limit in Table 9.5(a) (ACI, 2005) for minimum thickness without deflection calculation is not met by the proposed 6-inch slab. The alternative concrete slab is a one-way system due to the aspect ratio of the slab panel. The length of the slab is more than two times the width, ensuring that the slab is one-way for all zones with the exception of the east section of the women's shower wing. In order to meet the ACI thickness requirements, an 8-inch slab should be used with #5 at 10-inches on center (o.c.) as the main reinforcement. The secondary reinforcement consists of #4 at spacing of 12-inches o.c.

Since the alternative slab design is 2-inches thicker than the proposed design, the alternative design does use more concrete and is more expensive. **Error! Reference source not found.** Table 10 compares the quantities of concrete and the cost for the proposed design and the alternative design.

Table 10 Alternative slab design cost comparison

		Depth	Volume (CY)	Cost (per CY)	Total Cost
Slab	Proposed	6 inch	94.53	$114.00	$10,776.58
	Alternative	8inch	126.67	$114.00	$14,440.62

The increase in thickness of the slab does not affect the constructability of the system. The 2-inch increase in the top-of-slab elevation does not prove a significant impact on the clear height to the ceiling, but may pose issues in relation to ADA requirements of maintaining a flush finish with other aspects of the building.

A second alternative retains the 6" slab design yet meets the ACI minimum requirements to avoid deflection calculation by reducing the aspect ratio of the slab size to less than 2:1. The solution is to include an additional 10" grade beam where the largest span occurs, as noted in red in Figure 26. The 10" grade beam is designed in the 10" x 30" Grade Beam section of the appendix.

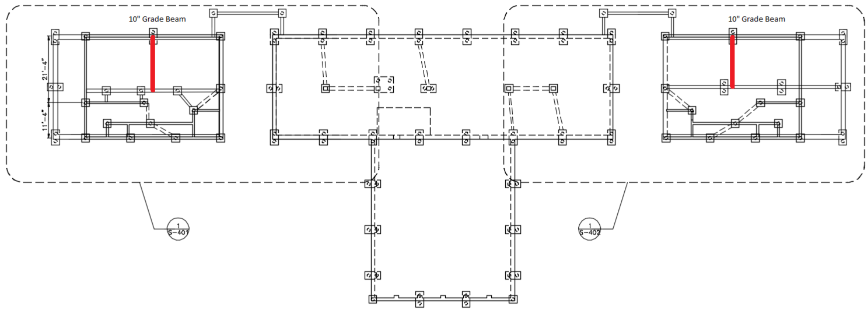


Figure 26 Slab design alternate 2: Additional grade beams

Design Process

The slab design process began by assuming a slab thickness, h, based on ACI Table 9.5(a) (Howells, A1fstad, Victor, Goldstein, & Remme, 2005). From that assumed thickness, an effective depth, d, was assumed. Typically, this is h-1", which is sufficient cover for slabs. The factored load was determined to calculate the expected moment on the slab. Using the expected moment, as well as a tributary width of 1ft as the base and the assumed d, the required reinforcement ratio was calculated. From reinforcement ratio ρ, the corresponding area of steel per foot of slab width was established. The area of steel was converted into equivalent bar size, and the spacing was checked to ensure the reinforcement, spacing, and cover fit within the dimensions of the slab. Using the newly defined area of steel, the moment capacity was checked. If the moment capacity exceeded the expected moment, the design of the slab and main reinforcement was complete. If not, the slab and reinforcement were redesigned. The secondary reinforcement, which is used to combat shrinkage in the slab, was then determined. The ratio of reinforcement is multiplied by the assumed base, 12", and the height of the slab. Spacing is calculated in the same manner as the regular reinforcement. The shear capacity is calculated and compared to the expected shear. If half of the capacity is larger than the expected shear, then the slab passes. If not, it must be redesigned to account for the shear. Typically, shear does not control the design of one-way slabs (Al-Manaseer, 2008).

3.2.3 Grade Beam Design

Two alternative designs for the grade beams were designed and analyzed. The partial plan in **Error! Reference source not found.** shows the location of the beams. The top dimension is from alternative (1) and the bottom dimension is from alternative (2). The portico beam has only one option

(12" x 18").

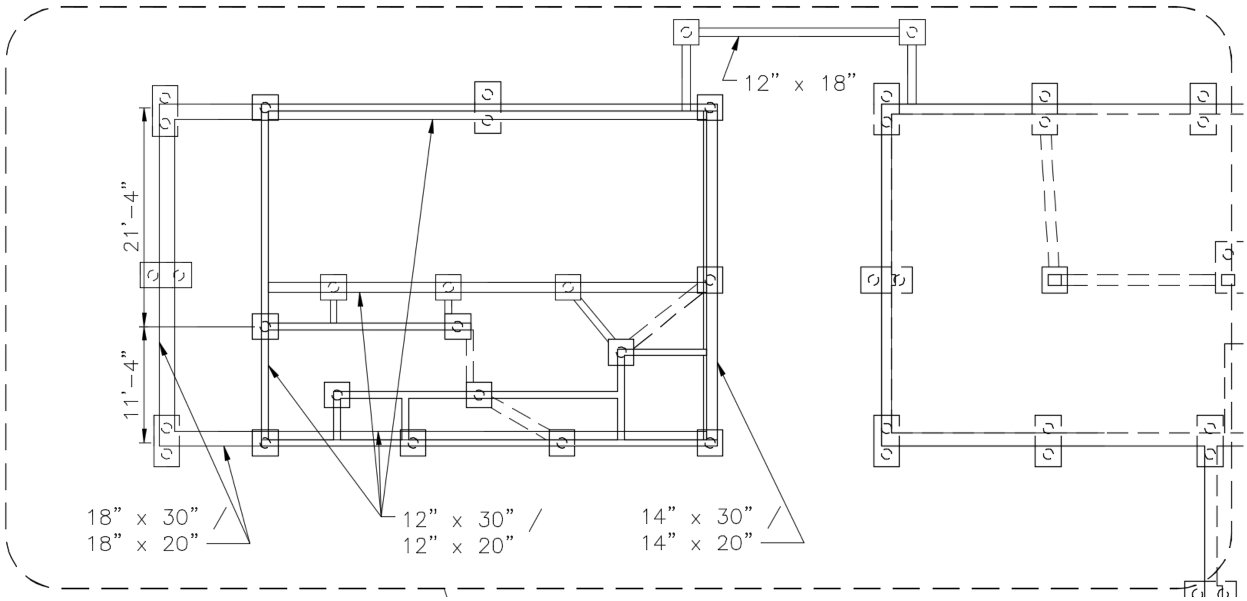


Figure 27 Grade Beam Plan View (partial)

Alternate (1) contains the design of two different sized beams: 10" x 30" and 10" x 18". The reinforcement configurations for the respective beams are shown in Figure 27. The beam depth for the 10" x 30" was based on the 30" depth of the existing grade beam design. The benefit of maintaining the consistent depth is to assist in the alignment of the foundation.

The 10" x 18" beam is to support the slab beneath the portico. Since the portico is new construction and not renovation, there is no existing grade beam in that location to match. Additionally, the portico is supported by columns placed on pile caps. As a result, the grade beams do not support the portico load. Rather, this grade beam supports the load from the concrete slab as well as pedestrian live load. The 10" x 18" grade beam for the portico is the same for both alternative designs.

The 10" x 30" grade beam abuts the existing 8" grade beam on the north and south walls. The beam is designed to support the expected load from the tributary area, allowing a factor of safety in the case that the existing grade beam is in poor condition. The width of the beam allows for the wall and slab overlap to fit. The wall sits directly on the grade beam as does the slab. Figure 65 in Appendix A shows a section of the wall, slab, and grade beam.

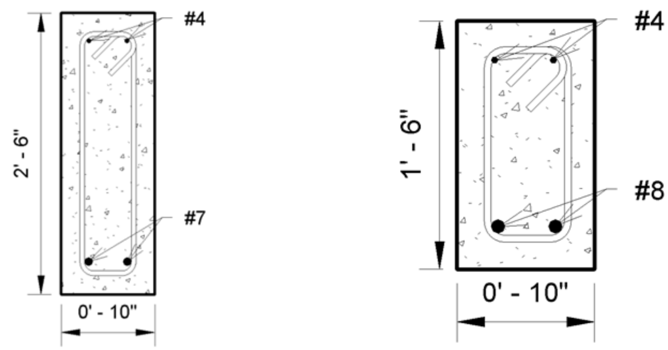


Figure 28 Reinforcement design of Alternate (1) Note: Not to Scale

Analysis of the proposed design for the grade beams along the east and west walls (18” x 30”) indicated that they are sufficient based on the design constraints of the wall size and slab overlap. The alternative design was based on the constraint to maintain a consistent 30-inch depth of the beam along the building foundation. Additionally, the thickness of the wall and the overlap of the slab require the beam to have a width of at least 18 inches. As a result of these considerations, the design of the beam was predominantly a matter of establishing its geometry, followed by defining the reinforcement. Analysis of the proposed design is located in the Proposed Grade Beam Design section of the Appendix.

Alternative (2) has three beam designs in addition to the portico beam design of Alternative (1). The beam sizes are 18” x 20”, 12” x 24”, and 14” x 24”. The reinforcement configurations for these beams are shown in Figure 30. The location of the grade beams for each of the alternative designs are shown in Figure 29.

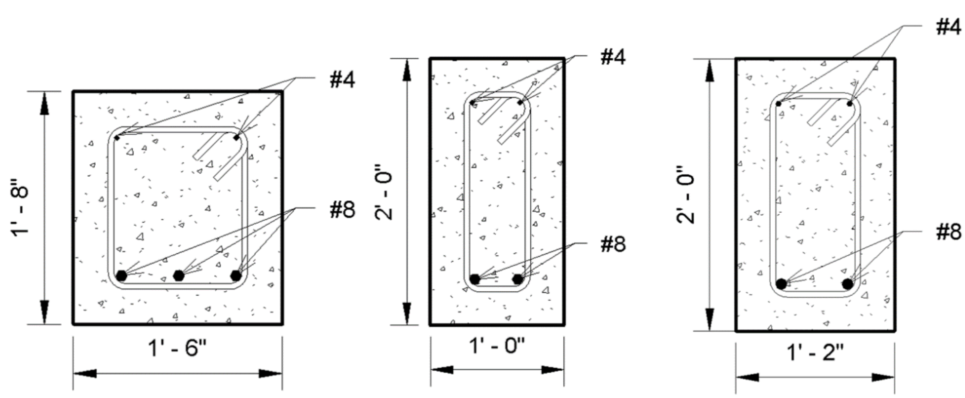


Figure 29 Reinforcement design of Alternate (2) Note: Not to Scale

The calculations for Alternative (2) are located in the Appendix under "Alternative Beam Design Calculations 2".

The analysis of the beam determined that each of the foundation grade beams are tension controlled as defined by ACI 10.5 (See Alternate Beam Design Calculations in the Appendix). As a result, the beams are not required to contain compression reinforcement. However, the beams require shear reinforcement in the form of stirrups. As a result, top reinforcement was included to facilitate the fabrication and installation of the stirrups.

Comparisons of the cost and volume of concrete are presented in Figure 30 Concrete volume and cost calculations. Alternative (1) and the proposed design maintain the same geometric design for each of the beams but specify different reinforcement. As a result, the cost estimate of Alternative (1) and the proposed design are essentially equal. Alternative (2) uses less concrete, resulting in a savings of $523.92.

Concrete Calculation			Length	Volume	
Grade Beams		Inches	in	in^3	ft^3
Alt. (1) and Proposed	b	18	1208	652320	377.5
	h	30			
	b	10	2048	614400	355.5556
	h	30			
	b	12	1244	447840	259.1667
	h	30			
	b	10	776	139680	80.83333
	h	18			
	Total			1854240	1073.056
	Total Cost ($90/yd^3)			$3,573.28	

Concrete Calculation			Length	Volume	
Grade Beams		Inches	in	in^3	ft^3
Alt. (2)	b	18	1208	434880	251.6667
	h	20			
	b	12	2048	589824	341.3333
	h	24			
	b	14	1244	417984	241.8889
	h	24			
	b	10	776	139680	80.83333
	h	18			
	Total			1582368	915.7222
	Total Cost ($90/yd^3)			$3,049.36	

Figure 30 Concrete volume and cost calculations

The grade beam design provided by Stantec is shown in the Grade Beam Design section of the Appendix. The proposed design of the grade beams has reinforcement placed in the compression zone, tension zone, and in mid-height of the beam. Two alternate beam designs were prepared: one set matches the depth of the existing grade beam and the second set reduces the depth of the beams. The calculations for the alternate designs are located in the Alternate Grade Beam Design sections of the Appendix.

Design Process

The design process for the reinforced concrete grade beams followed an iterative method that began with assumptions of the beam dimensions based on the span length. ACI 9.5 provides a table to estimate required width and depth. The total area of steel was calculated based on a ratio of required steel that accounts for the expected moment, strength of the concrete, and the dimensions of the beam. The required ratio of steel was compared to the required area of tension steel. This comparison determines if the beam is tension controlled or compression controlled. If tension controlled, the singly reinforced design process is sufficient. If compression controlled, the beam must be designed using the doubly reinforced beam method. The rebar size and quantity were chosen based on the total area of required steel and ACI 7.5 spacing limits. The reinforcement configuration must fit within the beam, assuming a minimum cover of 3 inches and a clear cover equal to the diameter of the steel chosen.

Once the configuration of the longitudinal steel was determined, the shear and diagonal tension were analyzed to determine the necessary shear reinforcement and spacing. Using a shear interaction diagram for the beam, the distance at which shear reinforcement is no longer needed was calculated. However, each of the beams in this design require shear reinforcement is for over 90% of its total length. It was determined, for ease of constructability, that the shear reinforcement layout be consistent throughout the beam.

The development lengths were calculated using ACI equation 12.2.2 for development length in bars size 7 and larger as well as bars size 6 and smaller. Additionally, ACI 12.3 provides the specification for development lengths of compression members

The structural walls sit directly atop the grade beams, ensuring that deflection must be controlled to prevent deformation throughout the building. The deflection was calculated by first ensuring the beam thickness meets ACI Table 9.5(a) for beams. If the beam meets the thickness requirements, the deflection may be calculated. If not, the design process returns to the original step with a new value for beam thickness. The deflection was calculated at mid-span by summing the deflection due to distributed load with the deflection due to point loads. The key elements of the deflection calculation are as follows:

- Length of clear span
- Distributed Load/Point Load
- Modulus of Elasticity of concrete
- Moment of Inertia of section

Simply supported beams were assumed for the grade beams. The total deflection was compared to the allowable deflection for the beam condition in ACI 9.5(b). The beam dimension and/or the reinforcement configuration are adjusted until the beam is under the deflection limit.

3.2.4 Pile Cap Design

The alternative design for the pile cap is shown in **Error! Reference source not found.**, which displays the dimensions of the component as well as the reinforcement layout and the geometry relative to the location of the piles. This alternative design meets the same dimensions as the pile cap design proposed by Stantec. The dimensions are the minimum allowed by ACI Chapter 15 for a two-pile system with 12" diameter concrete piles. Most notably, the pile cap must meet the edge spacing of 9 inches, the middle span (from pile to pile) is a minimum of 2 feet, and the piles must extend at least 6 inches into the pile cap. The size and arrangement of reinforcement for the alternative, though, is different from that of Stantec's design. The alternative pile cap design contains 6 #7 bars in the long direction and 8 #7 bars in the short direction. In contrast, Stantec's proposed design contains 3 #5 and 6 #6 in the long and short direction, respectively. The alternative pile cap will contain the same arrangement of dowels as for Stantec's proposed design.

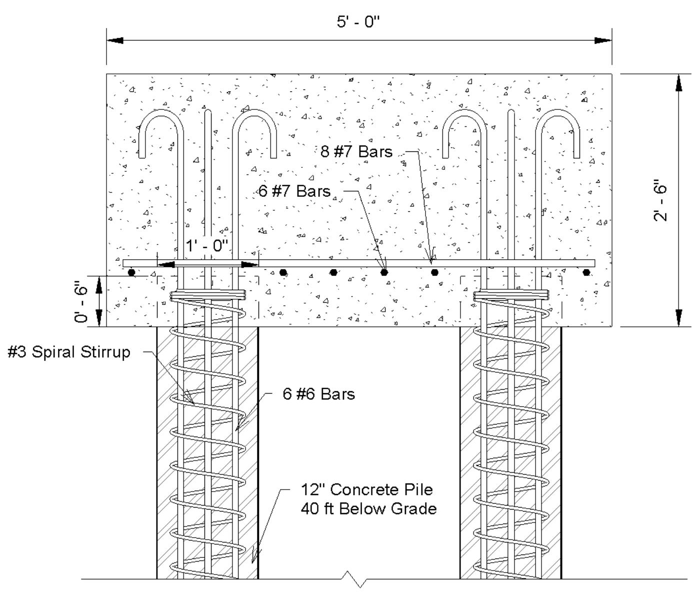


Figure 31 Pile Cap Design

The geometry of the alternative pile cap design follows the same dimension as the design proposed by Stantec. The reinforcement layout, however, will increase the price by a small margin due to the larger quantity of reinforcement. However, this cost difference is marginal and the two designs can be viewed as the same cost per unit.

Table 11 Pile cap cost comparison

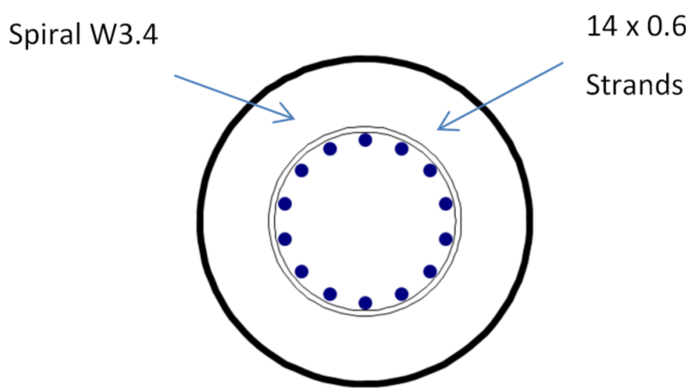
Pile Cap	Quantity	Capacity	Unit cost	Total Cost
Stantec Design	12	120 tons	$1,061.50	$12,738.00
Alternate Design	12	120 tons	$1,061.50	$12,738.00

Design Process

The pile cap follows the provision ACI 530 for pile cap design. The major design consideration for the pile cap was punching shear strength to resist the reaction force of the piles. The punching shear force of the piles is resisted by the depth of concrete and the reinforcement above the location of the piles. Since the dimensions of the pile cap are the minimum based on Chapter 15 of ACI 318-05, bending between the piles is not a concern. The pile cap includes reinforcement in both the short and long direction. The steel in the short direction is used as both shrinkage steel as well as incidental lateral moments. Since the piles are driven into the ground, there is the possibility of the pile being slightly askew. If that is the case, the reinforcement will be covered in both directions within the pile cap. The Pile Cap Design section of the Appendix contains the calculation sheet for the pile cap design. The design process required the expected loads and moments, as well as the size of the piles and the material properties. The reinforcement was designed for both the short direction and the long direction.

3.2.5 Pile Design

The pile design has two alternatives to the proposed design by Stantec: Prestressed and Cast-in-Place. The prestressed pile is 12” in diameter and 40 feet in unsupported length. The Pile Cap Design section of the Appendix contains the input parameters of the design and the calculated results. The pile contains 14 strands with a diameter of 0.6in. The pattern of the reinforcement layout is circular. The mild reinforcement is spiral shaped with a wire size of 3.4. The installation of the prestressed pile must conform to the PCI handbook for prestressed pile construction (PCI, 2010).



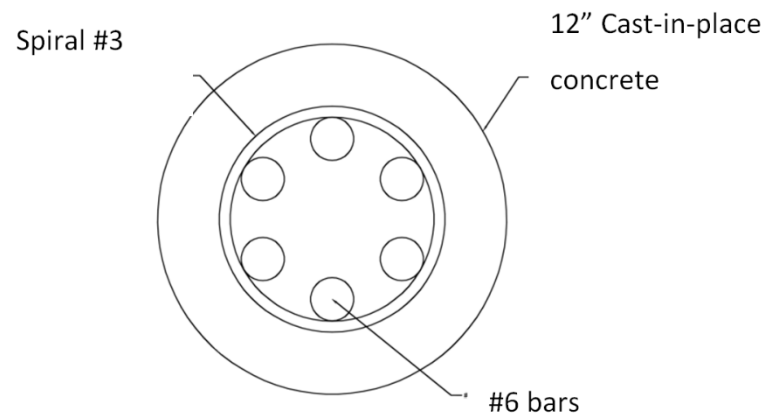


Figure 32 Prestressed Pile Cross-Section

Figure 33 Cast-in-place/Precast Pile Cross-Section

The second alternative for the pile design is cast-in-place reinforced concrete. The pile consists of 12” diameter cast-in-place concrete with 6 #6 rebar. The reinforcement is arranged in a circle with a spiral mild reinforcement of rebar #3. The Pile Design section of the Appendix contains the calculations for the design.

The cost comparison of the two proposed piles is in **Error! Reference source not found.**. The dimensions of the piles are the same, but the method of construction and production is different. The prestressed piles are $2,160.00 each and the cast-in-place piles are $1,704.00 each[1]. For the overall project, the cast-in-place option is roughly $10,000 more than the wood. The Prestressed is roughly $20,000 more than the wood pile option.

Table 12 Pile Type Cost Comparison

Pile Type	Quantity	Capacity	Unit cost	Total Cost
Prestressed 12" Diameter	23	184 tons	$2,160.00	$49,680.00
Cast-in-Place 12" Diameter	23	105 tons	$1,704.00	$39,192.00
Wood	23	40 tons	$1,280.00	$29,440.00

[1] Cost is from *RSMeans Heavy Construction Cost Data 2014*. The cost per linear foot was increased by the location factor for Long Island.

[2] Cost derived from *RSMeans Heavy Construction Cost Data 2014*. The estimate for shipping Prestressed Concrete Piles is $2 per linear foot for jobs of more than 10,000 linear feet. The unit cost of $10 per linear foot was

The proposed alternatives to the wood pile will increase the loading capacity and provide longevity. Wood piles that are located in an area susceptible to soil conditions that change from wet to dry are susceptible to rot. Based on the boring logs for the Robert Moses State Park's bathhouses, the soil is very sandy. This is leads to successful water dispersion through the soil, leaving the potential for both a wet and dry environment.

The prestressed concrete pile design provides greater strength compared to the cast-in-place design as well as timber piles. In addition to the performance advantage of the prestressed pile, it also reduces construction time. The pile is precast and shipped to the site for installation. However, this increases the cost of prestressed piles by about $10,000[2], in addition to the fact that the production of precast units is more expensive than cast-in-place.

The cast-in-place pile design can also be precast with the same reinforcement layout. This allows the pile to be driven into the ground and removes the need for a sleeve as well as pouring concrete at the site. In addition, precast concrete is closer to its full design strength, meaning it will have full strength (about 6 ksi) when installed.

The installation of concrete piles must conform to all ACI and PCI provisions for precast/cast-in-place and prestressed piles, respectively. Precast piles are installed using high compressive strength hammers, which can result in various forms of concrete failure such as cracking and spalling. Section 5.2 of ACI 543R states the concerns and preventative measures for precast pile installation.

Design Process

The prestressed pile was designed using the PCI Interaction Diagram Spreadsheet. The input and output of the spreadsheet is located in the Pile Design section of the Appendix. The spreadsheet requires assumptions to be made in regards to section type and strand size, as well as the input of design points for loading. The output of an interaction diagram shows if the assumptions made allow the pile to perform within the acceptable combination of axial and moment loads. If the design points do not lie within the acceptable load range, new assumptions must be made. The cast-in-place pile was designed using the ACI 530 design manual. The spreadsheet for the calculations is located in the Pile Design section of the Appendix. The area of steel was calculated with the assumption of pile dimensions.

[2] Cost derived from *RSMeans Heavy Construction Cost Data 2014*. The estimate for shipping Prestressed Concrete Piles is $2 per linear foot for jobs of more than 10,000 linear feet. The unit cost of $10 per linear foot was interpolated from the cost estimates due to the reduced number of piles (920 linear feet).

The load capacity was then calculated using the previously determined area of steel. If the load capacity did not exceed the expected load, new pile dimensions and/or steel arrangement were chosen until the load capacity exceeded the allowable loads.

4 Conclusions

Collaboration was required throughout this project between the architectural and structural disciplines to ensure coordination between the alternative designs and determine cost-effective solutions. The building information model portrays the synchronization between the architectural and structural design components.

Energy Efficiency Design

Stantec's proposed renovations of Field 5 Bathhouse give a performance energy savings of 15.8 percent and a cost savings of 16.1 percent over the baseline building, exceeding the 10 percent prerequisite for sustainable renovations of existing buildings in New York as specified in EO 111. Improving the building envelope by increasing the wall insulation to R-13.3 and roof insulation to R-25 increase the performance energy savings to an additional 5.9 percent and cost savings to 6.0 percent from Stantec's proposed design. Therefore, it is recommended to increase the insulation within the wall and roof. Additionally, increasing the area of solar panels across the entire ocean side roof and both sides of the roof on the dining area provides a 96.9 percent electricity cost reduction relative to Stantec's proposed design. As a result, it is strongly suggest to increase the area of solar panels.

Recommendations for further studies include simulating the bathhouse with normal year round use to better assess the building envelope improvements, evaluating insulation options for the walk-in refrigerators and freezers to reduce the electricity required to operate them, re-designing the HVAC system for better energy efficiency, and looking into solar hot water collectors to reduce the natural gas energy use and cost.

Public Shower Structures Design

The alternative design for the women's public shower area increased the total number of fixtures as desired by OPR&HP without expanding the size of the structure. Therefore, it is recommended to use the alternative layout for the women's shower area for future bathhouse renovations. This will provide 15 toilets, 10 lavatories, 4 hand dryers, 11 shower stalls, and 9 dressing compartments. On the other hand, it is recommended that Stantec's design be used for the men's public shower area because the alternative layout only increased the supplies storage area by 2.5 percent but required modifications to the shower dividers. The proposed design provides a sufficient storage area of 604 square feet and 9 shower stalls and 7 dressing compartments.

Higher-End Exterior Aesthetic Design

Should the client desire an alternative aesthetic, it is recommended that the brick, lap siding, and shingles be considered as a new look for the Field 2 Bathhouse. With brick masonry along the bottom perimeter, the bathhouse design coordinates with the other facilities, while the lap siding and shingles incorporate an attractive coastal-theme look.

Structural Design

The structural alternative designs are summarized in the cost comparison table at the end of this chapter. The design alternatives are based on various factors such as performance, cost, constructability, and code requirements. The advantages and disadvantages were weighed to provide the following design recommendations for each component:

Roof Design

The design provided by Stantec is the lowest cost alternative to meet the client's needs. The alternative design using glued laminated wood provides more clearance in the attic; however, the material cost is significantly increased. The construction also uses fewer members, but the individual members are more difficult to erect than the stick-frame counterpart. The truss option does not provide more attic clearance and costs significantly more. As such, the 2" x 14" wood framing design is the recommended option for the bathhouse. If future renovations of Field 5, or the other bathhouses, necessitate renovation of the main dining area, glued laminated may be the best option since the aesthetics of the engineered lumber can be utilized, possibly justifying the extra cost.

For further study, the use of light-frame wood trusses can be explored to determine if there is cost savings compared to the dimensional lumber framing. The heavy timber trusses allow for greater on-center spacing, but are significantly more expensive. The light-frame wood truss system should be analyzed for its viability on future bathhouse projects.

Slab

Reducing the longest span length of the slab by adding two grade beams to meet ACI deflection requirements for a 6" slab is the most economical alternative. The 8" slab would be effective in meeting the code requirements, but it increases the cost of construction too much to implement as the design.

Grade Beam

Alternative 2 for the grade beam design provides the necessary strength requirements for the expected loads. The alternative design reduces the amount of concrete needed to provide a more cost effective option than the proposed design, which follows the beam dimensions of the existing structure. Additionally, Alternative 2 provides the variability of extending the rigid insulation of the building envelop as explained in the architectural section of the chapter.

Pile/pile cap

The cast-in-place pile design, which also may be precast, provides the best balance of cost and durability in the coastal environment. The prestressed piles are excessive when comparing the performance and cost to what the building requires. The timber piles are the most economical option, but are susceptible to rot in salt water environments, resulting in a lifespan of 75-100 years. Additionally, FEMA recommends the use of precast piles for masonry-type buildings due to the larger loads (FEMA, 2013). They are adequate in strength for the Field 5 facility, but underperform when compared to the concrete options. The timber piles, however, are capable of performing in tension due to the material properties of the wood. The concrete piles are not capable of performing under tension. If the piles are expected to undergo tension during service, concrete is not a suitable option since it will likely crack.

The alternative pile cap design utilizes the same dimensions as the proposed design, which conforms to the ACI minimum size for the pile cap configurations. The arrangement and size of rebar is changed to provide additional performance with the use of alternative pile types. The cost difference of the pile cap design is limited to the reinforcement, which is regarded as negligible.

Table 13 Structural Design Options Cost Comparison

Component	Option	Description	Project Cost
Roof	Stantec Design	2x12 at 16" oc	$9,500
	Timber Truss	See Appendix	$30,000
	Engineered Lumber Rafters and Ridge Posts	40' clear span at 16" oc	$20,000
Slab	6 in	Normal Wt. #5 rebar	$10,500
	6 in w/ Add. Beams	Normal Wt. #5 rebar	$13,000
	8 in	Normal Wt. #5 rebar	$15,000
Grade Beam	Stantec Design	See Appendix	$4,000
	Alt. 1	Same Size, Alt. Rebar	$4,000
	Alt. 2	Smaller Size, Alt. Rebar	$3,000
Pile Cap	Stantec Design	See Appendix	$14,000
	Alt. 1	Same Size, Alt. Rebar	$14,000
Pile	Timber	12" Round	$30,000
	Precast Concrete	12" Round	$40,000
	Prestressed Concrete	12" Round	$50,000

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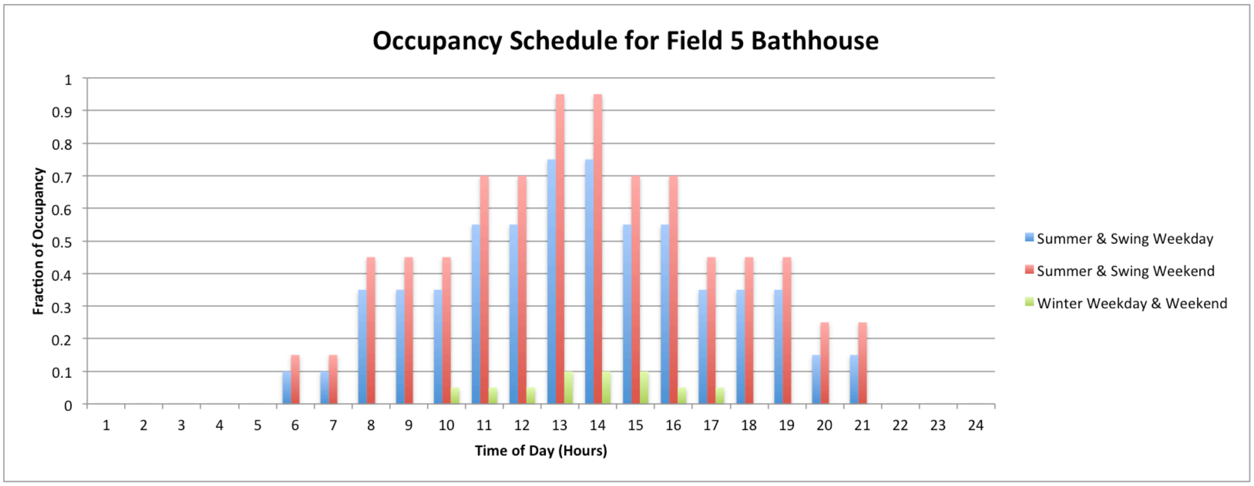
Appendices

Appendix A Energy Modeling

Display Mode: Occupancy

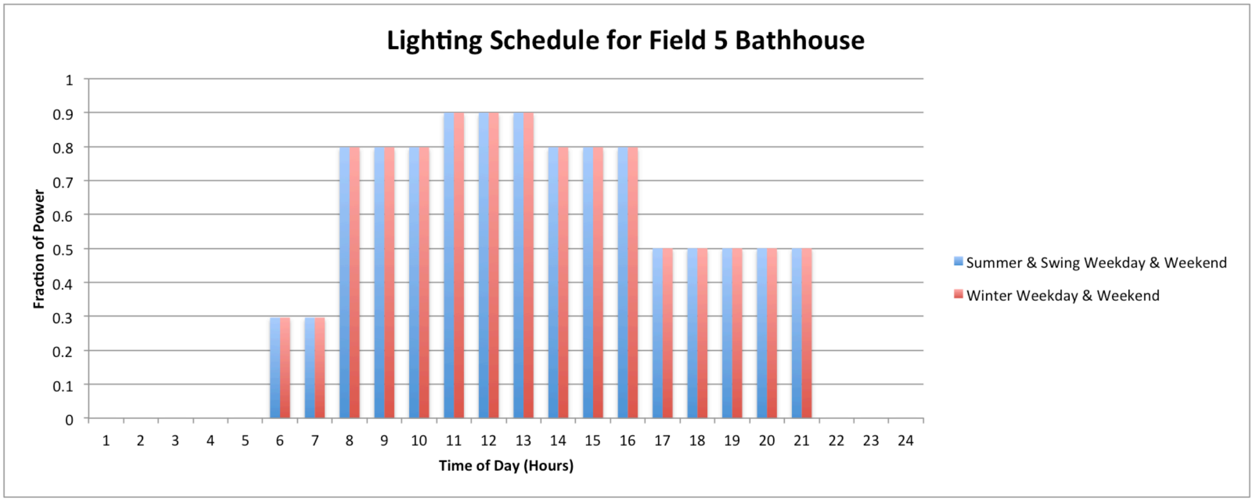
	Space Name	Parent Floor	Activity Desc.	Occupancy Schedule	Area/Person (ft2)	Number of People	Total Ht Gain (Btu/h-person)	People Sens (Btu/h-person)	People Lat (Btu/h-person)
1	EL1 SW Perim Spc (G.SW1)	EL1 Ground Flr	Retail / Wholesale Showrm	Bldg Occup Schedule w Shutdown	300	0.52	450	250	200
2	EL1 ENE Perim Spc (G.ENE2)	EL1 Ground Flr	Restrooms	Bldg Occup Schedule w Shutdown	300	0.57	450	250	250
3	EL1 NNW Perim Spc (G.NNW3)	EL1 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule w Shutdown	500	1.76	450	275	475
4	EL1 East Perim Spc (G.E4)	EL1 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule w Shutdown	500	0.12	450	275	475
5	EL1 South Perim Spc (G.S5)	EL1 Ground Flr	Locker and Dressing Room	Bldg Occup Schedule w Shutdown	100	5.47	450	255	475
6	EL2 SW Perim Spc (G.SW1)	EL2 Ground Flr	Medical and Clinical Care	Bldg Occup Schedule	200	1.38	450	250	200
7	EL2 Core Spc (G.C2)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.04	450	275	475
8	EL2 Core Spc (G.C3)	EL2 Ground Flr	Restrooms	Bldg Occup Schedule	300	0.07	450	250	250
9	EL2 Core Spc (G.C4)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.05	450	275	475
10	EL2 NW Perim Spc (G.NW5)	EL2 Ground Flr	Restrooms	Bldg Occup Schedule	300	2.26	450	250	250
11	EL2 South Perim Spc (G.S6)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.12	450	275	475
12	EL2 Core Spc (G.C7)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.04	450	275	475
13	EL2 North Perim Spc (G.N8)	EL2 Ground Flr	Mechanical/Electrical Room	Bldg Occup Schedule	2,000	0.24	450	250	250
14	EL2 North Perim Spc (G.N9)	EL2 Ground Flr	Kitchen and Food Prep	Bldg Occup Schedule	200	1.77	450	275	475
15	EL2 South Perim Spc (G.S10)	EL2 Ground Flr	Kitchen and Food Prep	Bldg Occup Schedule	200	0.64	450	275	475
16	EL2 South Perim Spc (G.S11)	EL2 Ground Flr	Restrooms	Bldg Occup Schedule	300	0.38	450	250	250
17	EL2 Core Spc (G.C12)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.11	450	275	475
18	EL2 North Perim Spc (G.N13)	EL2 Ground Flr	Office (General)	Bldg Occup Schedule	200	1.35	450	250	200
19	EL2 Core Spc (G.C14)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.04	450	275	475
20	EL2 Core Spc (G.C15)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.06	450	275	475
21	EL2 SE Perim Spc (G.SE16)	EL2 Ground Flr	Retail / Wholesale Showrm	Bldg Occup Schedule	300	1.07	450	250	200
22	EL2 NE Perim Spc (G.NE17)	EL2 Ground Flr	Restrooms	Bldg Occup Schedule	300	2.24	450	250	250
23	EL2 South Perim Spc (G.S18)	EL2 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	0.19	450	275	475
24	EL3 NNW Perim Spc (G.NNW1)	EL3 Ground Flr	Restrooms	Bldg Occup Schedule w Shutdown	300	0.50	450	250	250
25	EL3 Core Spc (G.C2)	EL3 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule w Shutdown	500	0.11	450	275	475
26	EL3 WSW Perim Spc (G.WSW3)	EL3 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule w Shutdown	500	0.48	450	275	475
27	EL3 SSE Perim Spc (G.SSE4)	EL3 Ground Flr	Locker and Dressing Room	Bldg Occup Schedule w Shutdown	100	6.19	450	255	475
28	EL3 NNE Perim Spc (G.NNE5)	EL3 Ground Flr	Restrooms	Bldg Occup Schedule w Shutdown	300	2.94	450	250	250
29	EL4 Spc (G.1)	EL4 Ground Flr	Dining Area	Bldg Occup Schedule	100	23.78	450	275	275
30	EL4 Under Roof (G.2)	EL4 Ground Flr	(no default)	- undefined -	n/a	n/a	n/a	n/a	n/a
31	EL5 West Perim Spc (G.W1)	EL5 Ground Flr	Storage (Conditioned)	Bldg Occup Schedule	500	16.92	450	275	475
32	EL5 Under Roof (G.2)	EL5 Ground Flr	(no default)	- undefined -	n/a	n/a	n/a	n/a	n/a

Figure 34 Assigning Activity Type Per Zone in eQuest Energy Model



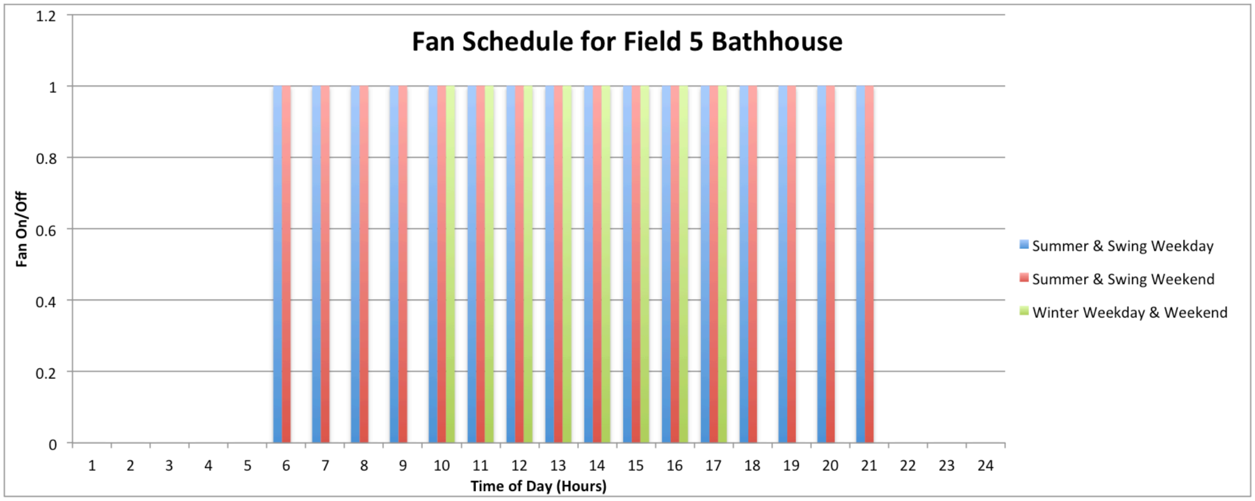
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Summer & Swing Weekday	0	0	0	0	0	0.1	0.1	0.35	0.35	0.35	0.55	0.55	0.75	0.75	0.55	0.55	0.35	0.35	0.35	0.15	0.15	0	0	0
Summer & Swing Weekend	0	0	0	0	0	0.15	0.15	0.45	0.45	0.45	0.7	0.7	0.95	0.95	0.7	0.7	0.45	0.45	0.45	0.25	0.25	0	0	0
Winter Weekday & Weekend	0	0	0	0	0	0	0	0	0	0.05	0.05	0.05	0.1	0.1	0.1	0.05	0.05	0	0	0	0	0	0	0

Figure 35 Building Occupancy Schedule



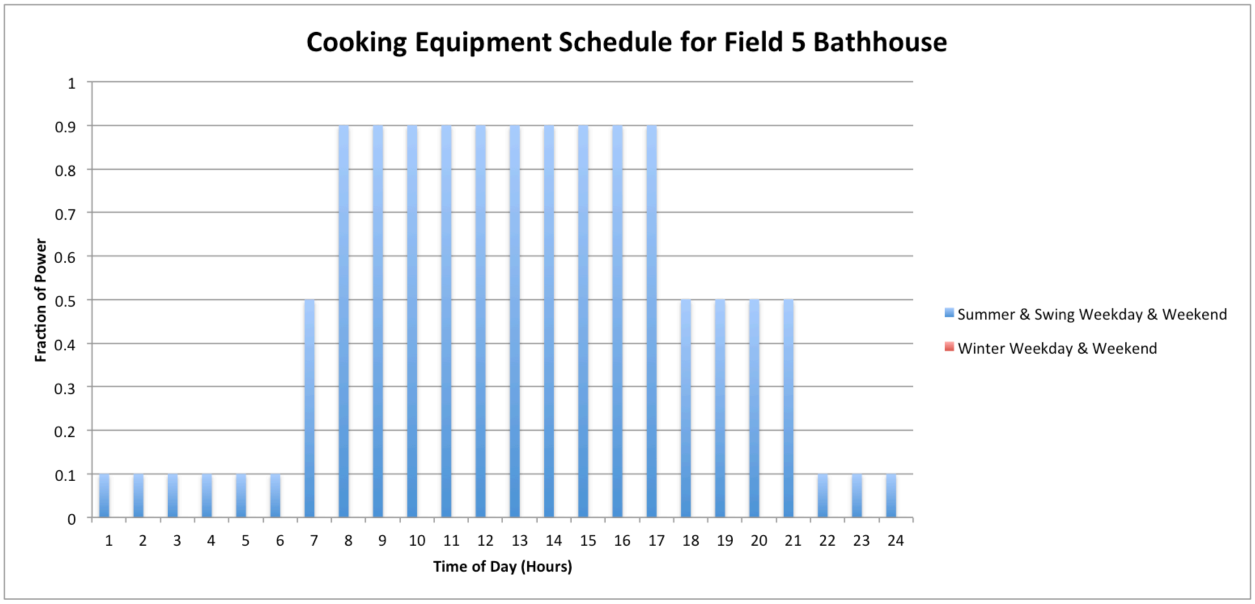
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Summer & Swing Weekday & Weekend	0	0	0	0	0	0.3	0.3	0.8	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0	0	0
Winter Weekday & Weekend	0	0	0	0	0	0.3	0.3	0.8	0.8	0.8	0.9	0.9	0.9	0.8	0.8	0.8	0.5	0.5	0.5	0.5	0.5	0	0	0

Figure 36 Building Lighting Schedule



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Summer & Swing Weekday	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Summer & Swing Weekend	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Winter Weekday & Weekend	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0

Figure 37 Building Fan Schedule



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Summer & Swing Weekday & Weekend	0.1	0.1	0.1	0.1	0.1	0.1	0.5	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.5	0.5	0.5	0.5	0.1	0.1	0.1
Winter Weekday & Weekend	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 38 Building Cooking Equipment Schedule Including Walk-In Refrigerator and Walk-In Freezer

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Summer & Swing Weekday	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80	80
Summer & Swing Weekend	80	80	80	80	80	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	80	80	80
Winter Weekday & Weekend	80	80	80	80	80	80	80	80	80	75	75	75	75	75	75	75	75	80	80	80	80	80	80	80

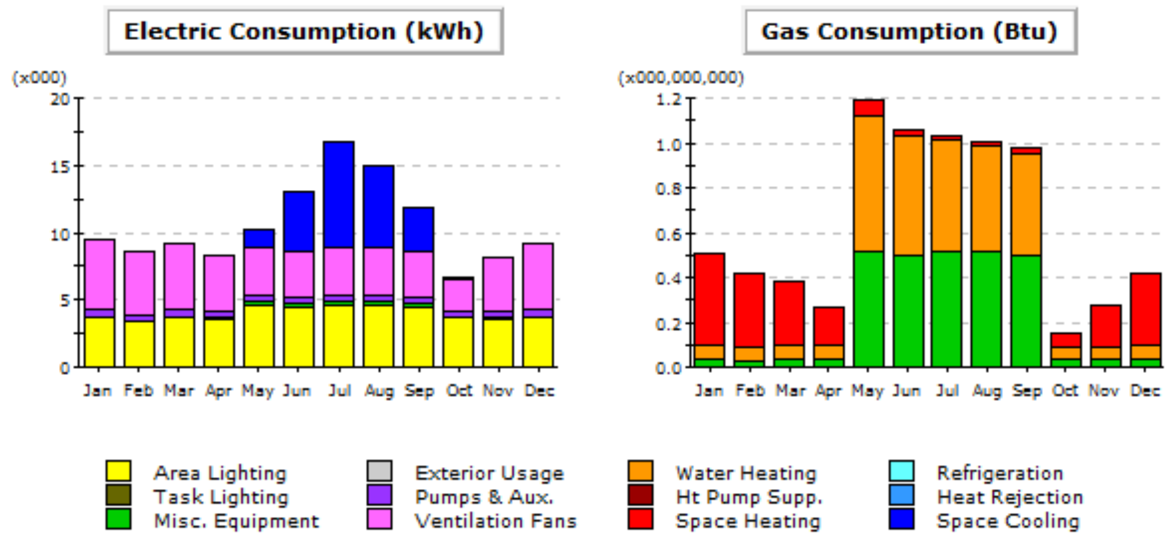
Figure 39 Building Cooling Schedule

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Summer & Swing Weekday	65	65	65	65	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	65	65	65
Summer & Swing Weekend	65	65	65	65	65	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	70	65	65	65
Winter Weekday & Weekend	65	65	65	65	65	65	65	65	65	70	70	70	70	70	70	70	70	65	65	65	65	65	65	65

Figure 40 Building Heating Schedule

Table 14 Lighting Wattage Per Zone for Field 5 Bathhouse

ZONE	LIGHTING WATTAGE	AREA	WATTS/SQ FT.	ASHRAE 90.1 VALUE	TOTAL ALLOWED
Men's Shower Structure					
Supplies Storage	189	621	0.30	0.63	986
Stairs "ST 3-2"	87	101	0.86	0.69	146
Beach Umbrella & Distribution	101	115	0.88	1.68	68
Men's Public Showers & Dressing Cubicles	322	437	0.74	0.75	583
Janitors Closet	29	39	0.74	0.63	62
Family Toilet	96	109	0.88	0.98	111
Main Bathhouse					
Men's Public Toilet	414	554	0.75	0.98	565
Janitors Closet	29	14	2.07	0.63	22
First Aid Toilet	29	15	1.93	0.98	15
Stairs "ST 2-2"	58	66	0.88	0.69	96
First Aid Storage	29	19	1.53	0.63	30
First Aid	180	233	0.77	1.66	140
Utility Room	252	450	0.56	0.95	474
Walk-in Freezer	0		0.00	0.63	
Walk-in Refridgerator	0		0.00	0.63	
Janitors Closet	29	16	1.81	0.63	25
Kitchen	468	266	1.76	0.99	269
Area Office	90	137	0.66	1.11	123
Cash Room	45	47	0.96	0.63	75
Staff Toilet	87	86	1.01	0.98	88
Dry Storage	117	94	1.24	0.63	149
Storage under Stair "ST 1-2"	58	63	0.92	0.63	100
Women's Public Toilet	414	565	0.73	0.98	577
Janitors Closet	29	13	2.23	0.63	21
Storage	29	26	1.12	0.63	41
Beach Shop	270	271	1.00	1.68	161
Stairs "ST 1-2"	58	85	0.68	0.69	123
Women's Shower Structure					
Women's Public Toilet	368	595	0.62	0.98	607
Women's Public Showers & Dressing Cubicles	460	646	0.71	0.75	861
Janitors Closet	29	42	0.69	0.63	67
Stair	58	98	0.59	0.63	156
Family Toilet	92	115	0.80	0.98	117
Attic					
Attic	764	6281	0.12	0.63	9970
TOTAL	5280	12219			16829



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.01	0.01	1.30	4.49	7.91	6.07	3.24	0.08	-	-	23.10
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	5.16	4.68	4.91	4.12	3.55	3.36	3.47	3.47	3.36	2.35	3.96	4.89	47.30
Pumps & Aux.	0.55	0.49	0.53	0.47	0.47	0.45	0.46	0.46	0.45	0.43	0.49	0.53	5.78
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.04	0.04	0.04	0.04	0.29	0.29	0.29	0.30	0.29	0.04	0.04	0.04	1.75
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	3.72	3.36	3.72	3.60	4.63	4.48	4.63	4.63	4.48	3.72	3.60	3.72	48.28
Total	9.47	8.56	9.21	8.25	10.24	13.08	16.76	14.93	11.82	6.62	8.08	9.19	126.21

Gas Consumption (Btu x000,000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.41	0.33	0.28	0.17	0.07	0.03	0.02	0.02	0.03	0.06	0.19	0.32	1.94
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.07	0.06	0.07	0.06	0.60	0.53	0.50	0.47	0.45	0.06	0.06	0.06	2.97
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.03	0.03	0.03	0.03	0.52	0.50	0.52	0.52	0.50	0.03	0.03	0.03	2.78
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.51	0.42	0.38	0.27	1.19	1.05	1.03	1.00	0.98	0.15	0.28	0.42	7.69

Figure 41 eQuest Baseline Monthly Energy Consumption by Enduse Results

Annual Energy Consumption by Enduse

	Electricity kWh (x000)	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	23.10	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	1,935.1	-	-
HP Supp.	-	-	-	-
Hot Water	-	2,970.1	-	-
Vent. Fans	47.30	-	-	-
Pumps & Aux.	5.78	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	1.75	2,780.8	-	-
Task Lights	-	-	-	-
Area Lights	48.28	-	-	-
Total	126.21	7,685.9	-	-

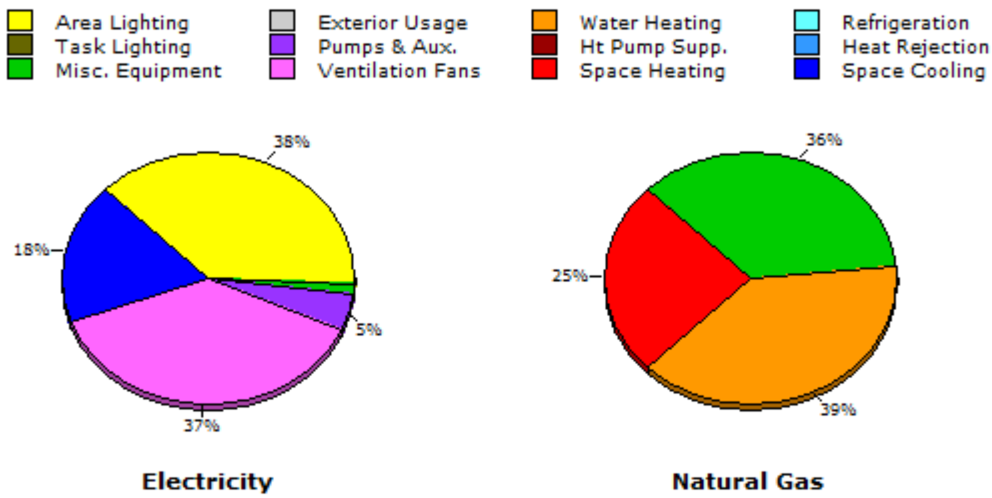


Figure 42 eQuest Baseline Annual Energy Consumption by Enduse Results

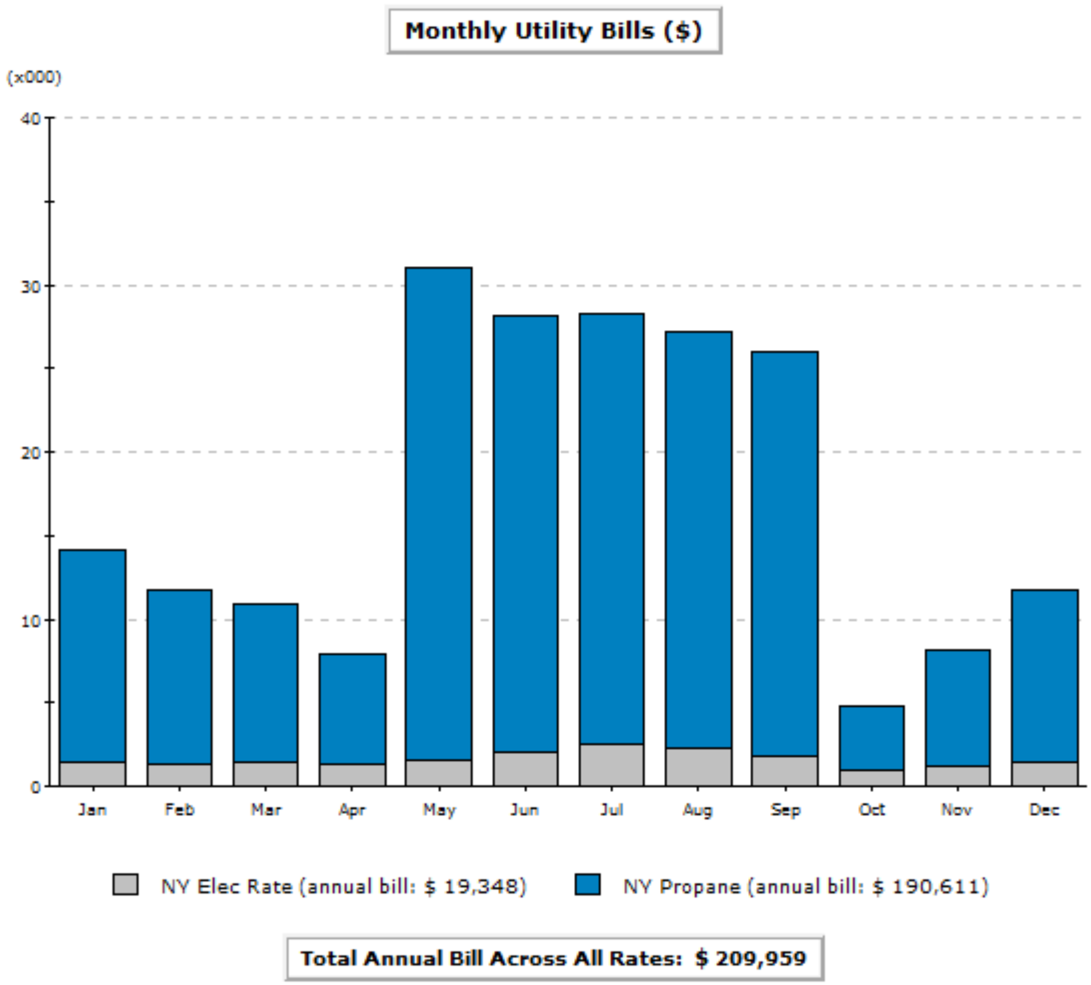
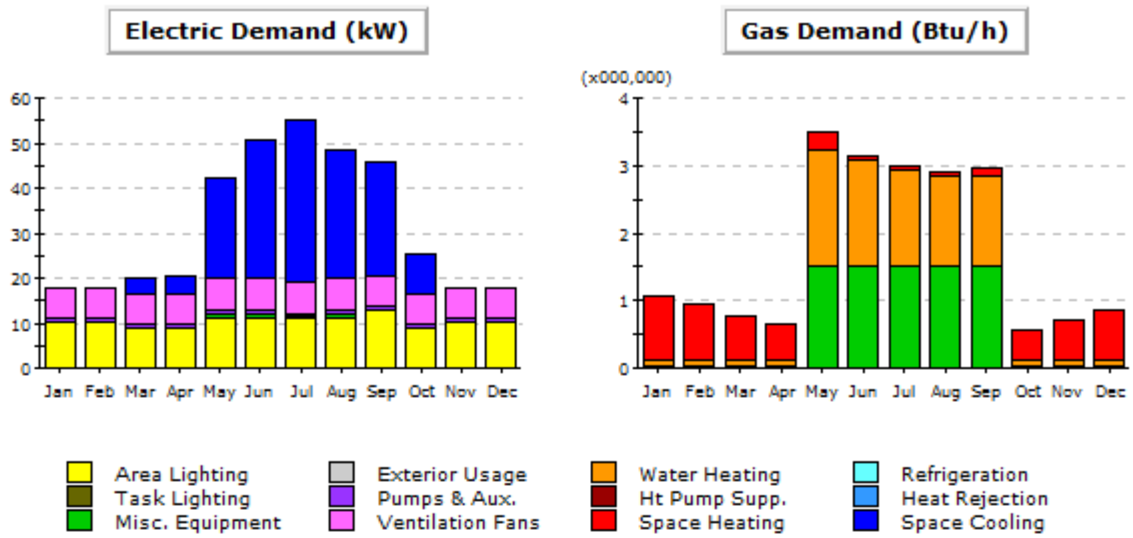


Figure 43 eQuest Baseline Monthly Utility Bills – All Rates Results



Electric Demand (kW)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	3.17	3.92	22.29	30.89	35.86	28.79	24.96	8.84	-	-	158.72
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	84.00
Pumps & Aux.	0.74	0.74	0.54	0.54	0.72	0.72	0.72	0.72	0.72	0.54	0.74	0.74	8.18
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.05	0.05	0.05	0.05	0.82	0.82	0.18	0.82	0.18	0.05	0.05	0.05	3.20
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	10.20	10.20	9.04	9.04	11.26	11.26	11.26	11.26	12.70	9.04	10.20	10.20	125.69
Total	17.99	17.99	19.81	20.56	42.09	50.69	55.03	48.59	45.57	25.48	17.99	17.99	379.79

Gas Demand (Btu/h x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.94	0.83	0.63	0.51	0.27	0.08	0.06	0.05	0.12	0.44	0.57	0.74	5.24
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.09	0.09	0.09	0.09	1.71	1.55	1.41	1.32	1.31	0.08	0.08	0.08	7.90
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.04	0.04	0.04	0.04	1.52	1.52	1.52	1.52	1.52	0.04	0.04	0.04	7.91
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	1.07	0.96	0.76	0.64	3.50	3.15	2.99	2.89	2.96	0.56	0.70	0.87	21.05

Figure 44 eQuest Baseline Monthly Peak Demand by Enduse Results

Annual Peak Demand by Enduse

	Electricity kW	Natural Gas Btu/h (x000)	Steam Btu/h	Chilled Water Btu/h
Space Cool	35.86	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	271.4	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,712.4	-	-
Vent. Fans	7.00	-	-	-
Pumps & Aux.	0.72	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	0.18	1,520.4	-	-
Task Lights	-	-	-	-
Area Lights	11.26	-	-	-
Total	55.03	3,504.2	-	-

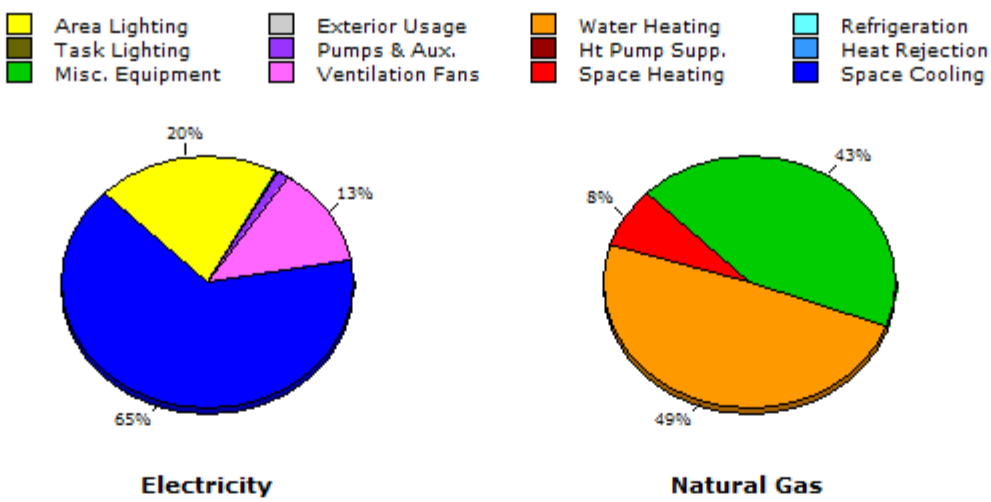


Figure 45 eQuest Baseline Annual Peak Demand by Enduse Results

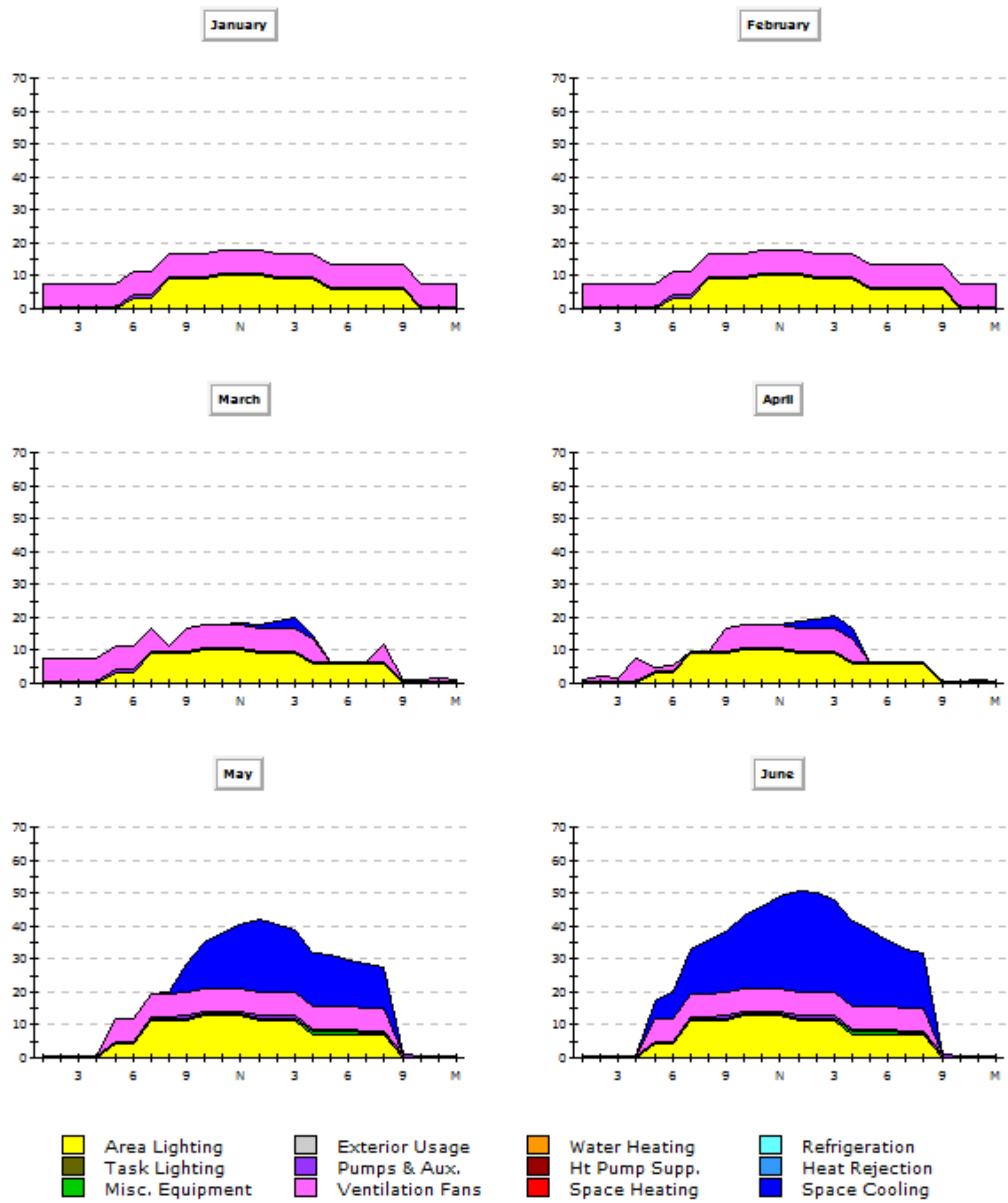


Figure 46 eQuest Baseline Monthly Electric Peak Day Load Profiles Results – January to June

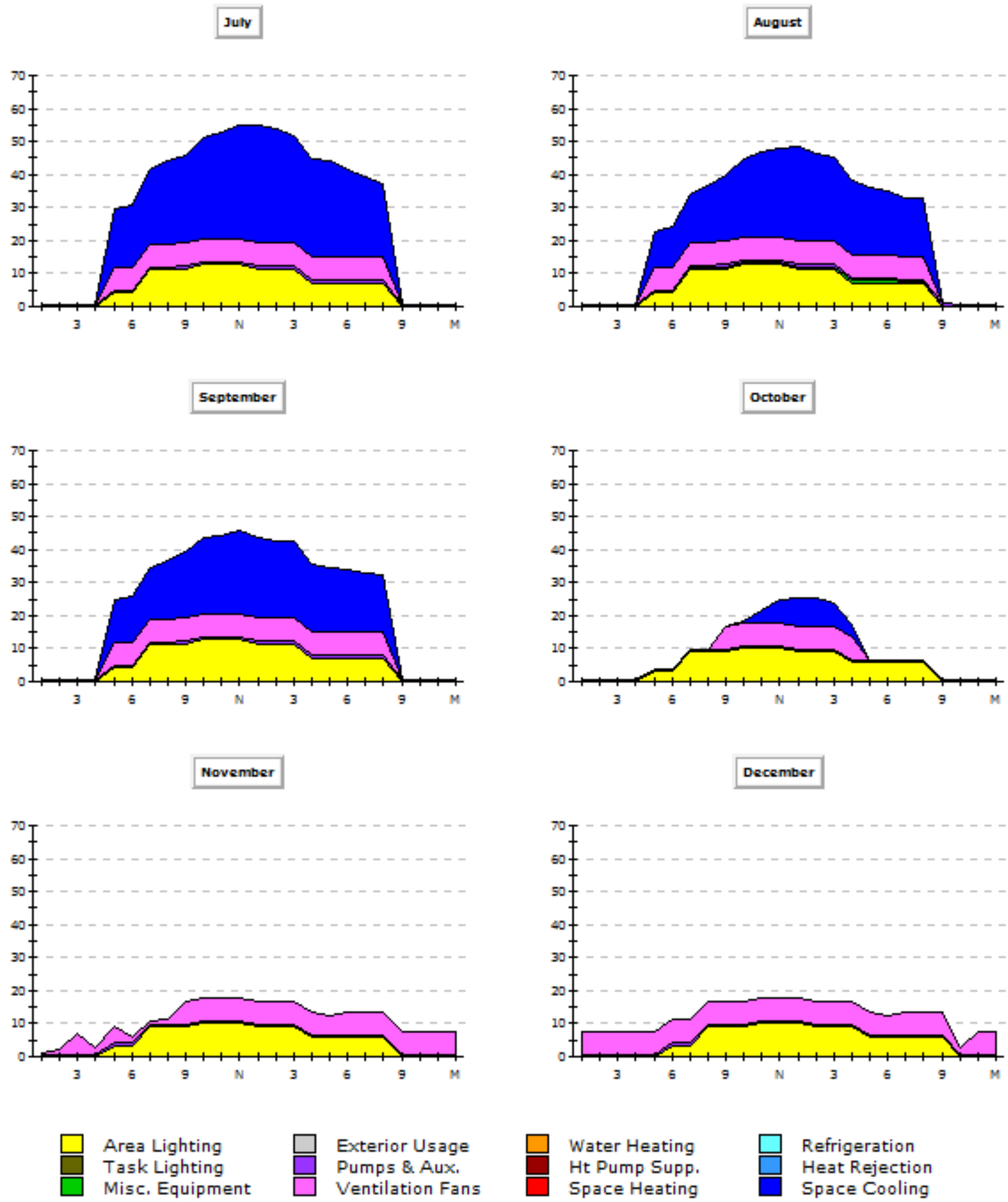
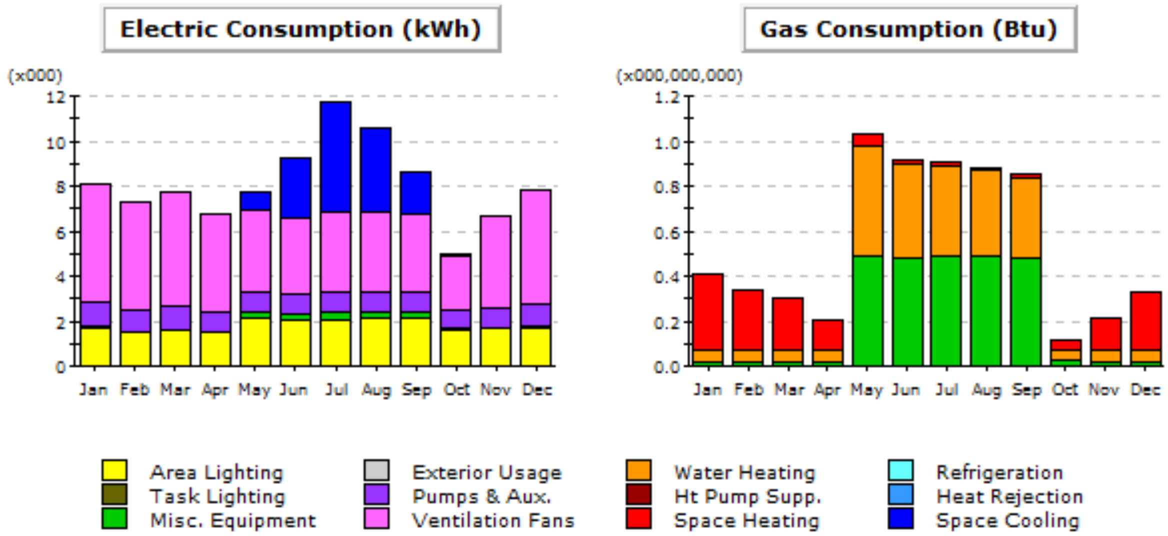


Figure 47 eQuest Baseline Monthly Electric Peak Day Load Profiles Results – July to December



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.00	0.00	0.73	2.66	4.92	3.67	1.88	0.02	-	-	13.89
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	5.30	4.80	5.06	4.31	3.65	3.45	3.56	3.56	3.45	2.44	4.06	5.03	48.66
Pumps & Aux.	1.04	0.93	0.99	0.89	0.92	0.87	0.90	0.89	0.87	0.83	0.91	1.00	11.05
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.04	0.04	0.04	0.04	0.29	0.29	0.29	0.30	0.29	0.04	0.04	0.04	1.75
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	1.73	1.49	1.60	1.48	2.12	2.01	2.08	2.11	2.12	1.62	1.65	1.73	21.73
Total	8.11	7.26	7.70	6.73	7.70	9.27	11.74	10.53	8.62	4.96	6.66	7.80	97.07

Gas Consumption (Btu x000,000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.34	0.27	0.22	0.14	0.05	0.01	0.01	0.01	0.02	0.05	0.15	0.26	1.52
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.05	0.05	0.05	0.05	0.48	0.43	0.40	0.38	0.36	0.05	0.05	0.05	2.41
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.02	0.02	0.02	0.02	0.49	0.48	0.49	0.49	0.48	0.02	0.02	0.02	2.58
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.41	0.34	0.30	0.21	1.03	0.92	0.90	0.88	0.86	0.12	0.22	0.33	6.50

Figure 48 eQuest Proposed Design Monthly Energy Consumption by Enduse Results

Annual Energy Consumption by Enduse

	Electricity kWh	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	13,885	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	1,519.8	-	-
HP Supp.	-	-	-	-
Hot Water	-	2,406.6	-	-
Vent. Fans	48,659	-	-	-
Pumps & Aux.	11,050	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	1,745	2,576.3	-	-
Task Lights	-	-	-	-
Area Lights	21,735	-	-	-
Total	97,074	6,502.7	-	-

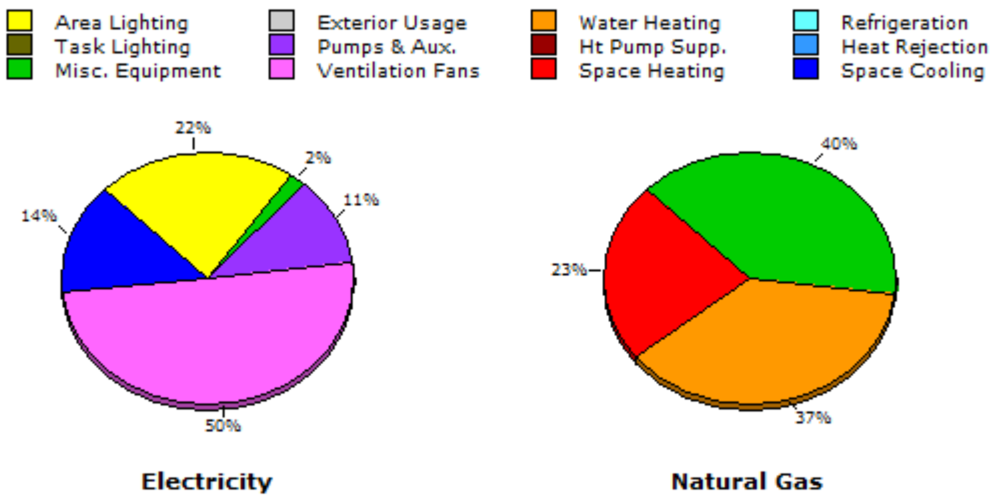


Figure 49 eQuest Proposed Design Annual Energy Consumption by Enduse Results

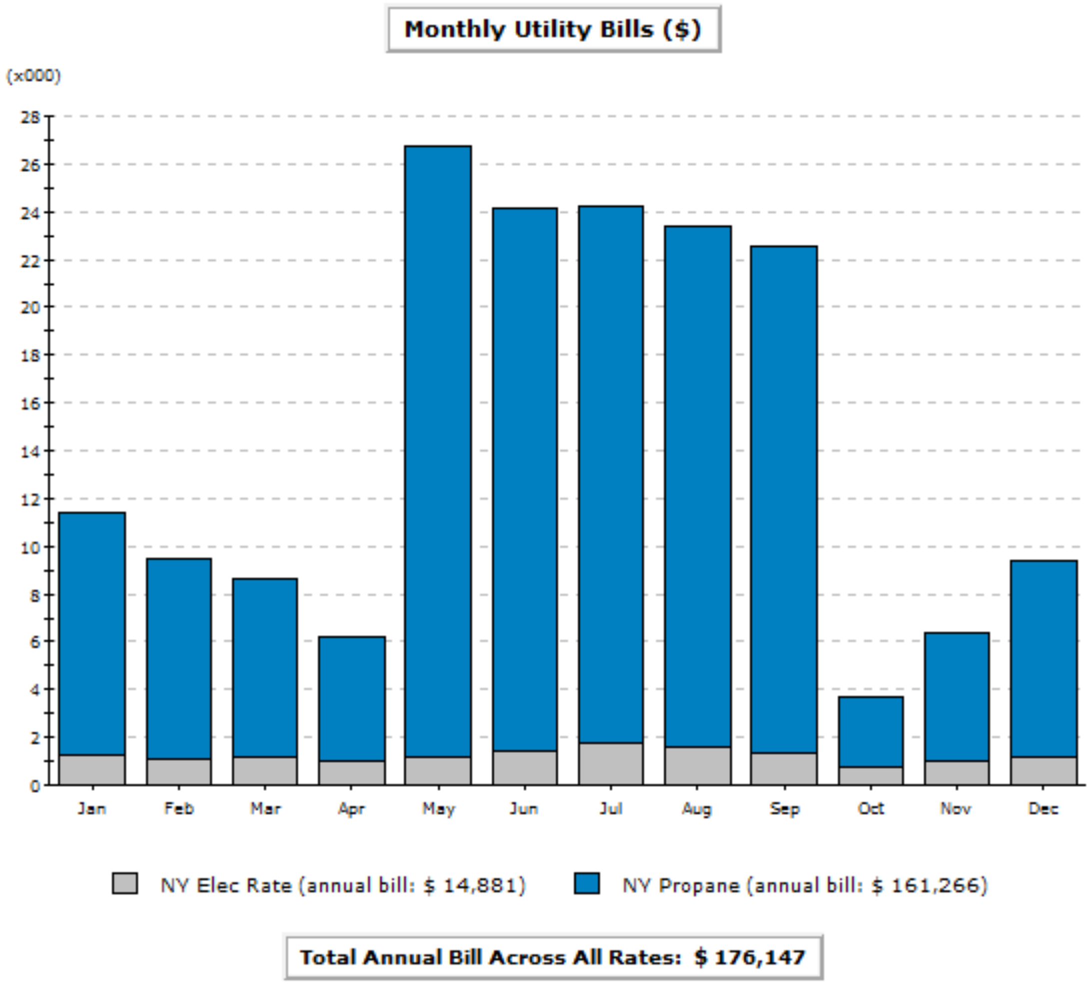
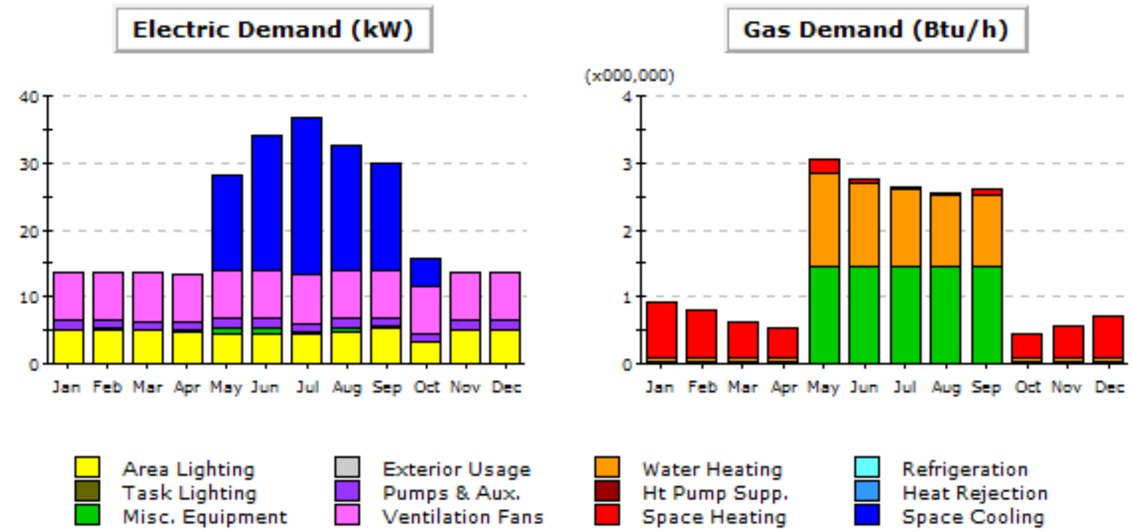


Figure 50 eQuest Proposed Design Monthly Utility Bills – All Rates Results



Electric Demand (kW)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	14.32	20.17	23.66	18.75	15.86	4.11	-	-	96.86
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	86.19
Pumps & Aux.	1.45	1.35	1.36	1.34	1.37	1.37	1.37	1.37	1.37	1.07	1.34	1.38	16.16
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.05	0.05	0.05	0.05	0.82	0.82	0.18	0.82	0.18	0.05	0.05	0.05	3.20
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	4.96	5.15	4.95	4.86	4.50	4.54	4.49	4.60	5.31	3.34	5.01	5.00	56.72
Total	13.64	13.74	13.55	13.44	28.19	34.09	36.89	32.72	29.91	15.75	13.60	13.62	259.14

Gas Demand (Btu/h x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.82	0.71	0.52	0.42	0.21	0.06	0.03	0.02	0.09	0.35	0.47	0.62	4.32
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.07	0.07	0.07	0.07	1.39	1.26	1.14	1.07	1.06	0.06	0.07	0.07	6.40
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.03	0.03	0.03	0.03	1.46	1.46	1.45	1.46	1.46	0.03	0.03	0.03	7.48
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.92	0.81	0.62	0.52	3.06	2.77	2.63	2.55	2.61	0.45	0.56	0.71	18.20

Figure 51 eQuest Proposed Design Monthly Peak Demand by Enduse Results

Annual Peak Demand by Enduse

	Electricity kW	Natural Gas Btu/h (x000)	Steam Btu/h	Chilled Water Btu/h
Space Cool	23.66	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	212.8	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,387.5	-	-
Vent. Fans	7.18	-	-	-
Pumps & Aux.	1.37	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	0.18	1,456.6	-	-
Task Lights	-	-	-	-
Area Lights	4.49	-	-	-
Total	36.89	3,056.9	-	-

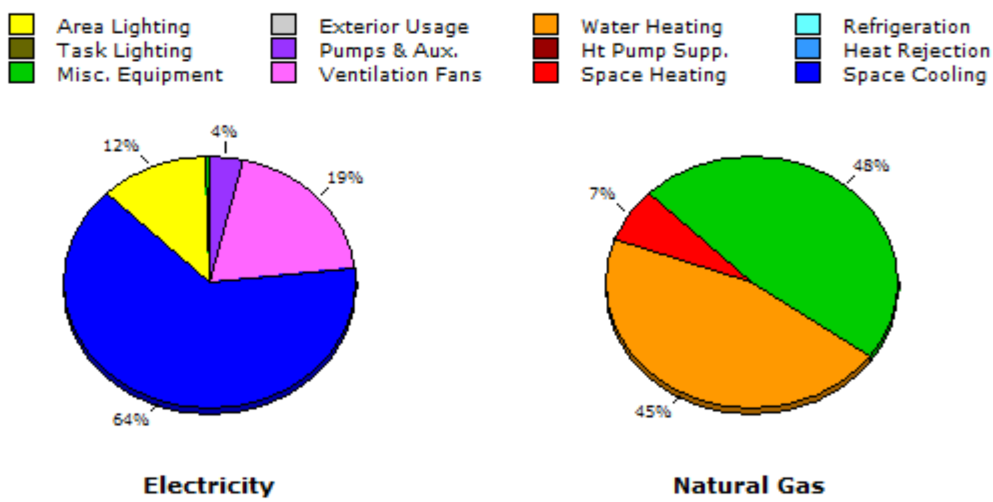


Figure 52 eQuest Proposed Design Annual Peak Demand by Enduse Results

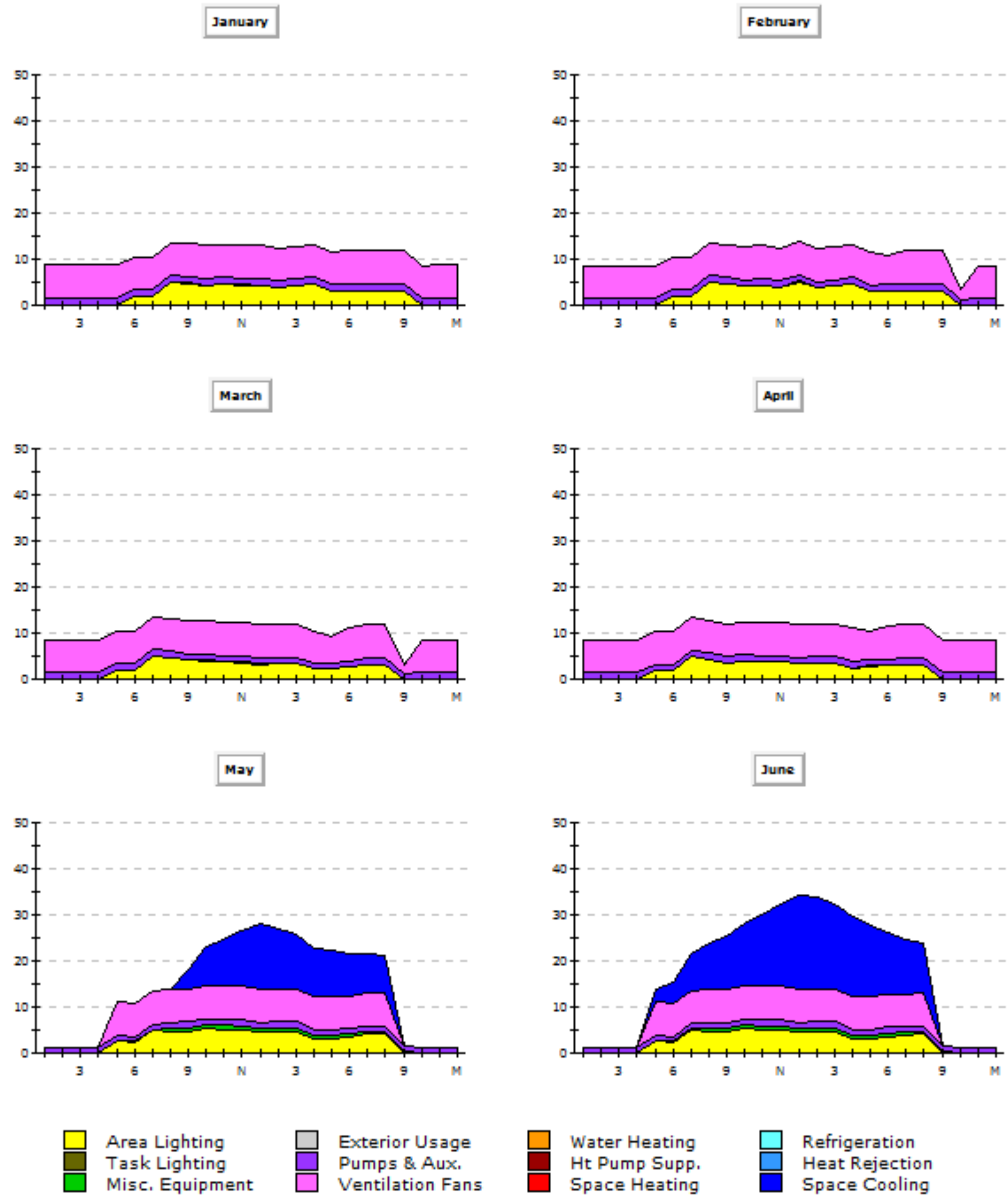


Figure 53 eQuest Proposed Design Monthly Electric Peak Day Load Profiles Results – January to June

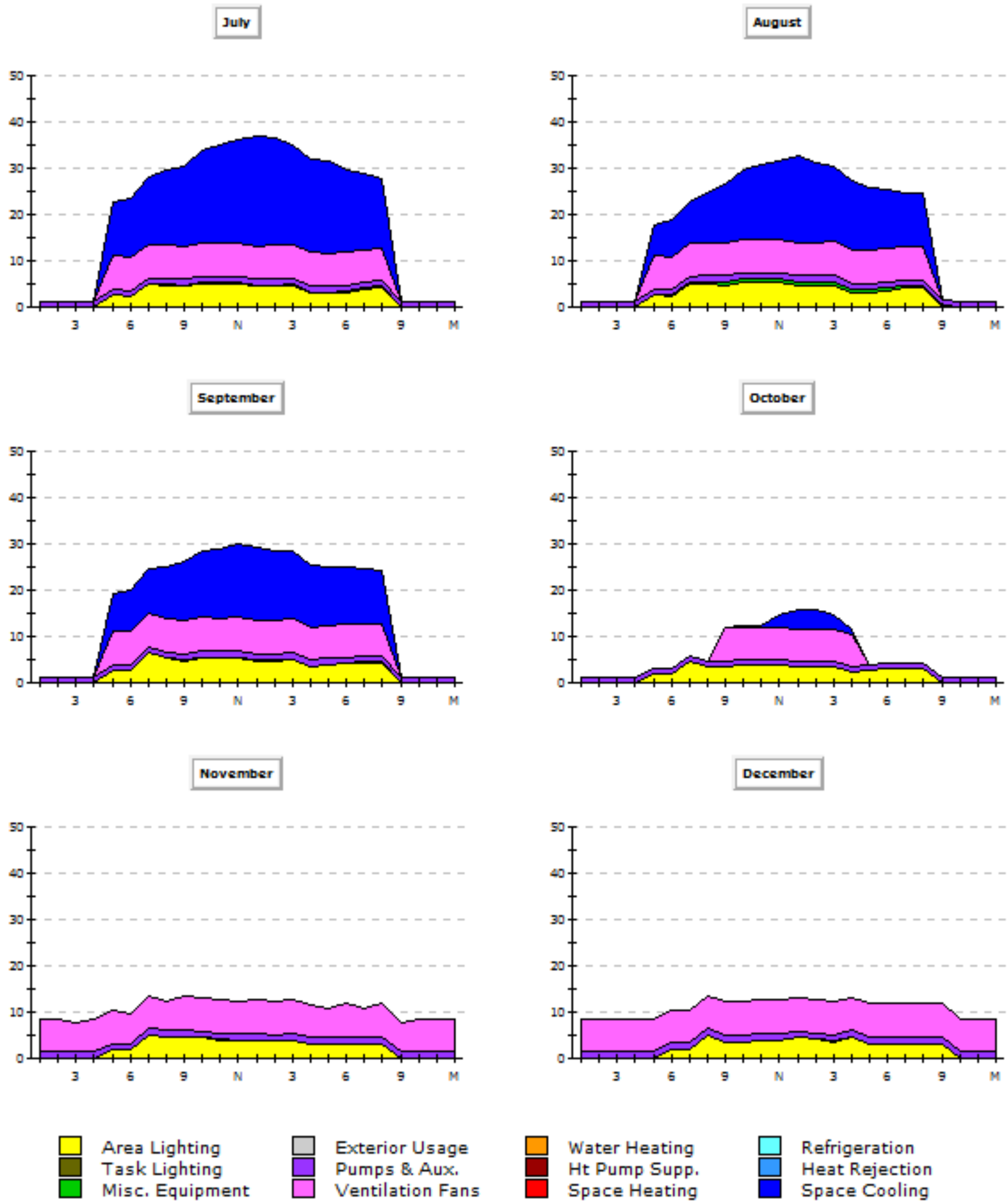
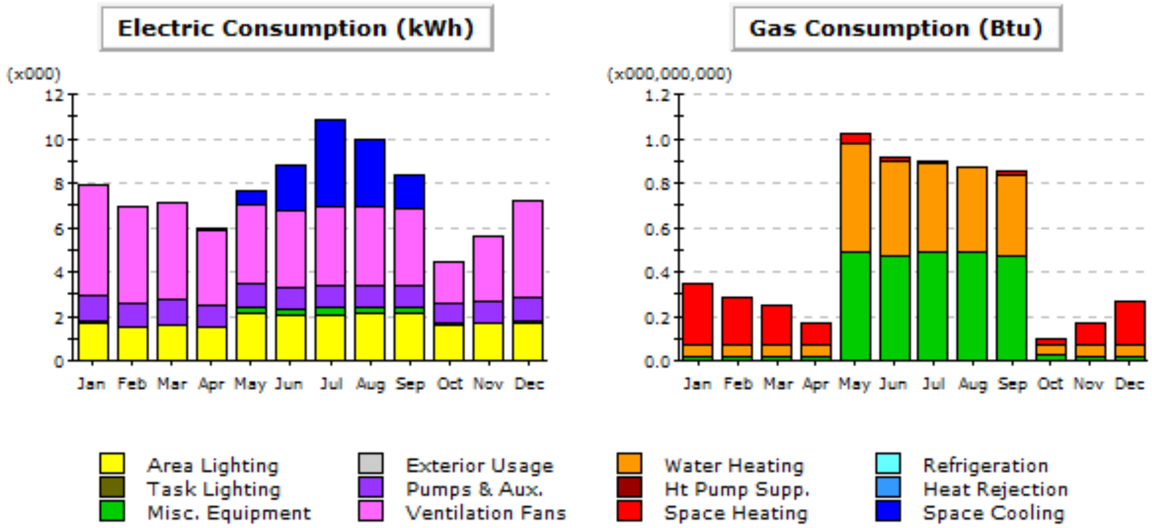


Figure 54 eQuest Proposed Design Monthly Electric Peak Day Load Profiles Results – July to December



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	0.00	0.00	0.60	2.12	3.90	3.01	1.56	0.03	-	-	11.22
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	4.98	4.36	4.41	3.41	3.58	3.45	3.56	3.56	3.45	1.84	2.90	4.37	43.87
Pumps & Aux.	1.12	1.00	1.07	0.97	1.02	0.97	1.00	1.00	0.97	0.92	0.99	1.08	12.12
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.04	0.04	0.04	0.04	0.29	0.29	0.29	0.30	0.29	0.04	0.04	0.04	1.75
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	1.73	1.49	1.60	1.48	2.12	2.01	2.08	2.11	2.12	1.62	1.65	1.73	21.73
Total	7.87	6.89	7.13	5.91	7.60	8.84	10.82	9.98	8.39	4.45	5.58	7.22	90.69

Gas Consumption (Btu x000,000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.27	0.21	0.18	0.10	0.05	0.01	0.00	0.00	0.01	0.03	0.10	0.20	1.16
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.05	0.05	0.05	0.05	0.48	0.43	0.40	0.38	0.36	0.05	0.05	0.05	2.41
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.02	0.02	0.02	0.02	0.49	0.48	0.49	0.49	0.48	0.03	0.02	0.02	2.58
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.35	0.28	0.25	0.17	1.02	0.91	0.90	0.87	0.85	0.10	0.17	0.27	6.14

Figure 55 eQuest Improved Design Monthly Energy Consumption by Enduse Results

Annual Energy Consumption by Enduse

	Electricity kWh	Natural Gas MBtu	Steam Btu	Chilled Water Btu
Space Cool	11,224	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	1,160.4	-	-
HP Supp.	-	-	-	-
Hot Water	-	2,406.3	-	-
Vent. Fans	43,872	-	-	-
Pumps & Aux.	12,118	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	1,745	2,575.6	-	-
Task Lights	-	-	-	-
Area Lights	21,735	-	-	-
Total	90,693	6,142.3	-	-

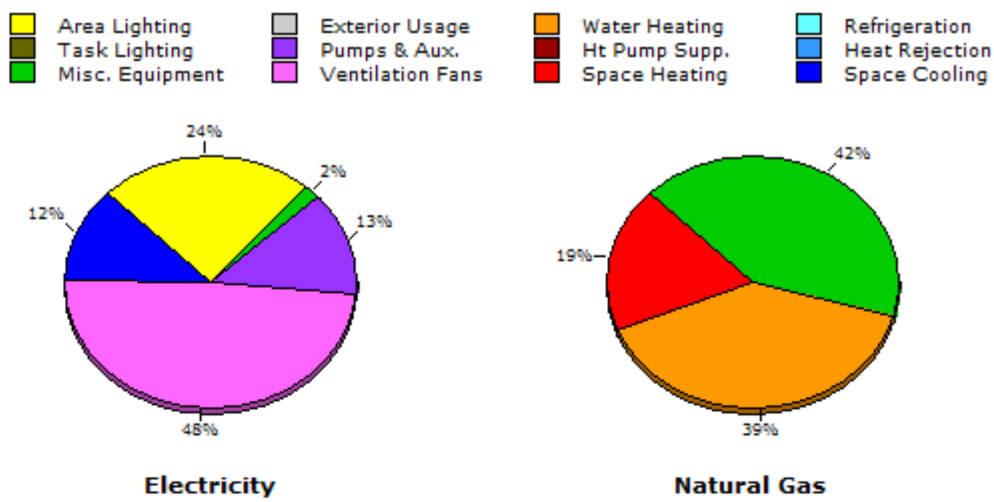


Figure 56 eQuest Improved Design Annual Energy Consumption by Enduse Results

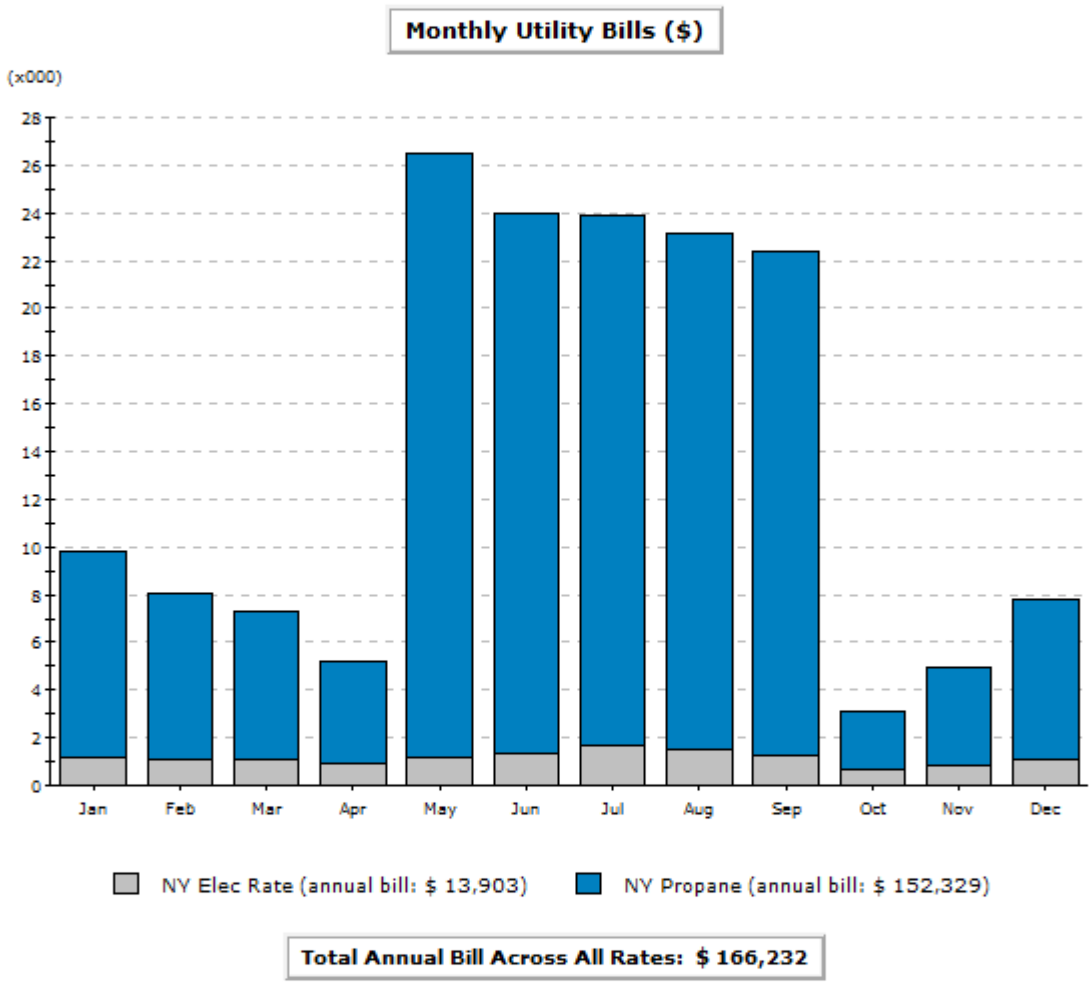
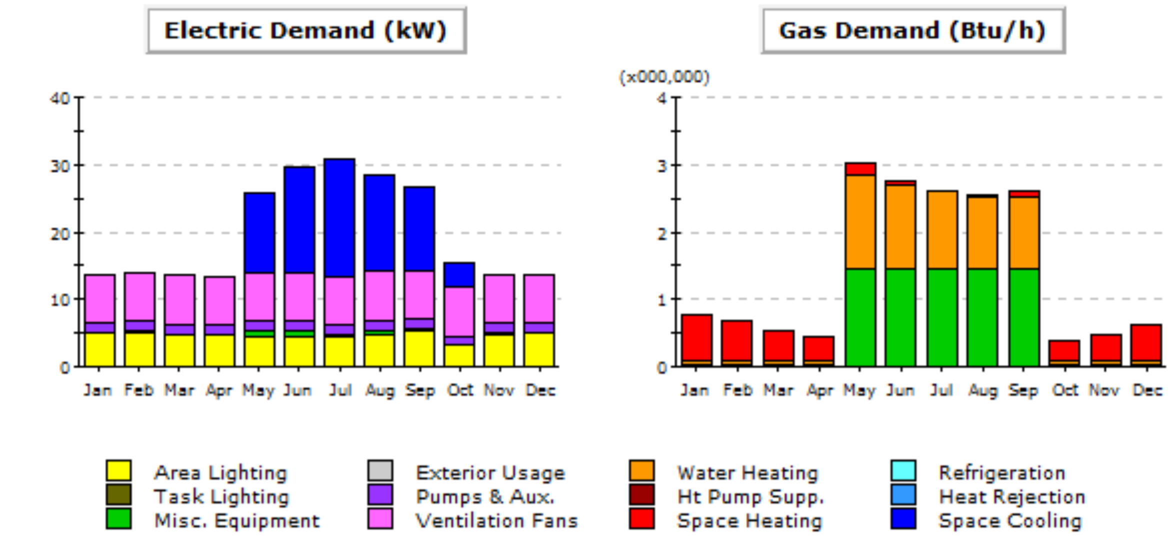


Figure 57 eQuest Improved Design Monthly Utility Bills – All Rates Results



Electric Demand (kW)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	11.66	15.61	17.30	14.38	12.58	3.78	-	-	75.32
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	7.18	86.19
Pumps & Aux.	1.55	1.47	1.50	1.49	1.53	1.53	1.53	1.53	1.53	1.19	1.49	1.50	17.84
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.05	0.05	0.05	0.05	0.82	0.82	0.18	0.82	0.18	0.05	0.05	0.05	3.20
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	4.96	5.15	4.79	4.72	4.50	4.54	4.49	4.60	5.31	3.32	4.86	5.00	56.24
Total	13.75	13.86	13.53	13.45	25.70	29.68	30.69	28.51	26.79	15.53	13.58	13.73	238.80

Gas Demand (Btu/h x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.67	0.58	0.44	0.36	0.19	0.05	0.02	0.01	0.08	0.28	0.39	0.52	3.60
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.07	0.07	0.07	0.07	1.39	1.26	1.14	1.07	1.06	0.06	0.07	0.07	6.40
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.03	0.03	0.03	0.03	1.46	1.46	1.45	1.45	1.45	0.03	0.03	0.03	7.47
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	0.77	0.68	0.54	0.46	3.03	2.76	2.62	2.54	2.60	0.37	0.49	0.61	17.47

Figure 58 eQuest Improved Design Monthly Peak Demand by Enduse Results

Annual Peak Demand by Enduse

	Electricity kW	Natural Gas Btu/h (x000)	Steam Btu/h	Chilled Water Btu/h
Space Cool	17.30	-	-	-
Heat Reject.	-	-	-	-
Refrigeration	-	-	-	-
Space Heat	-	187.7	-	-
HP Supp.	-	-	-	-
Hot Water	-	1,387.4	-	-
Vent. Fans	7.18	-	-	-
Pumps & Aux.	1.53	-	-	-
Ext. Usage	-	-	-	-
Misc. Equip.	0.18	1,456.0	-	-
Task Lights	-	-	-	-
Area Lights	4.49	-	-	-
Total	30.69	3,031.1	-	-

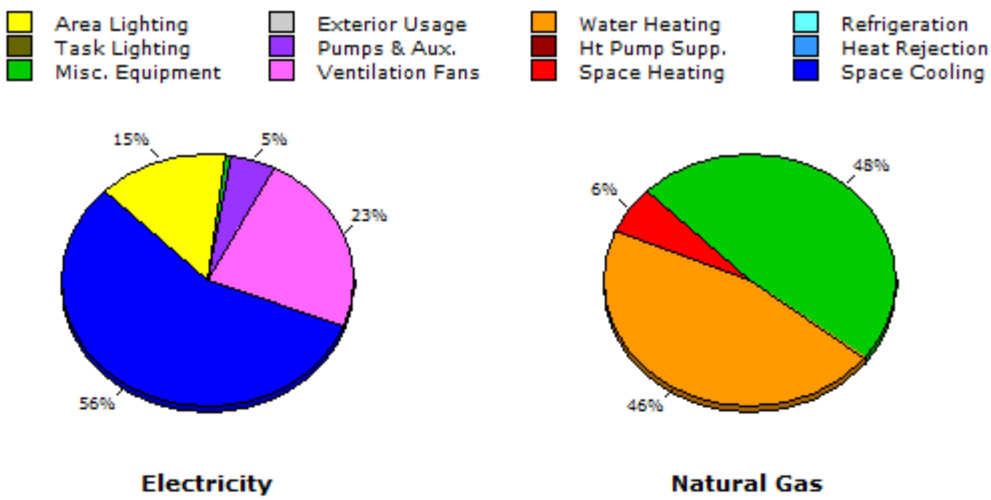


Figure 59 eQuest Improved Design Annual Peak Demand by Enduse Results

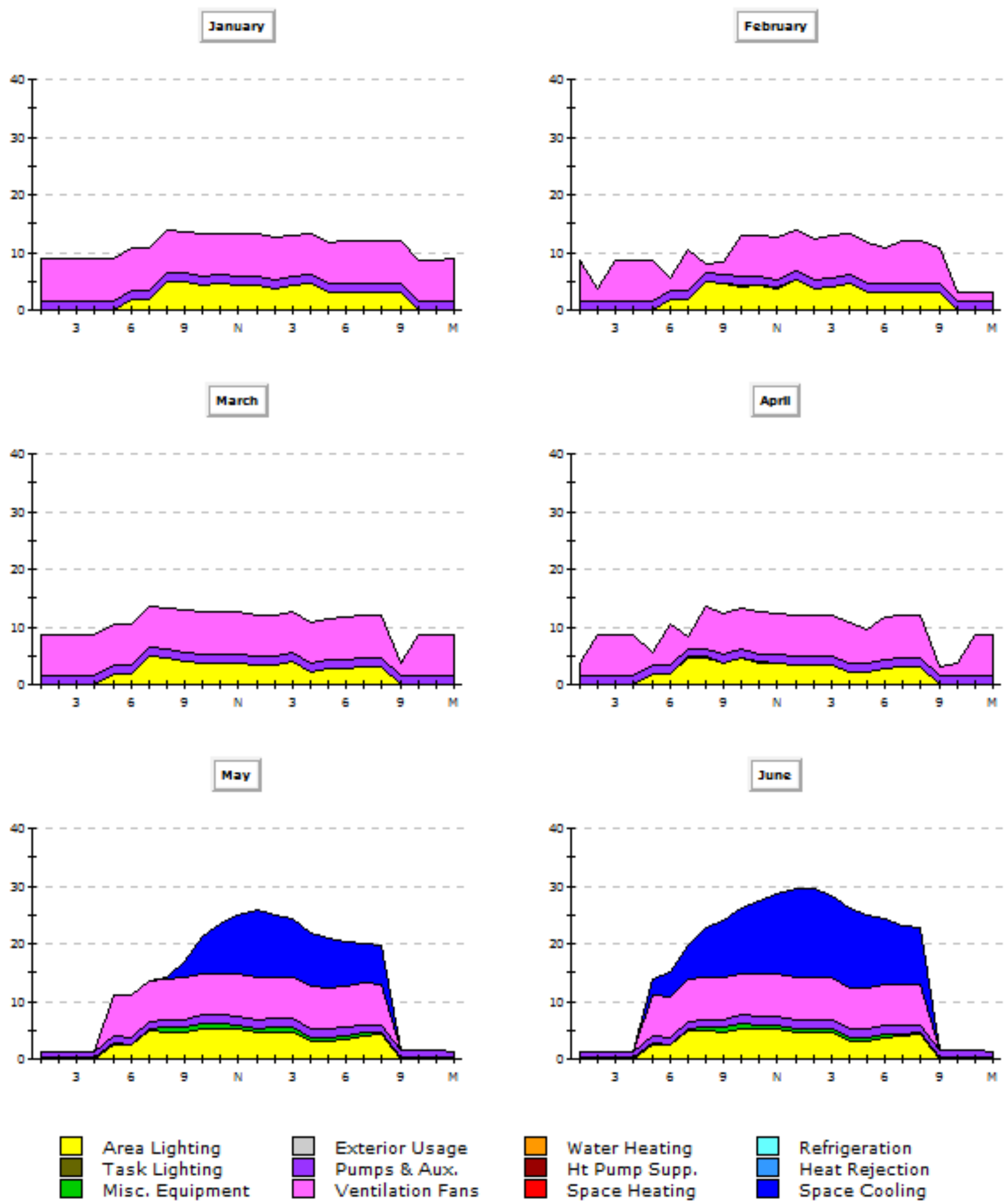


Figure 60 eQuest Improved Design Monthly Electric Peak Day Load Profiles Results

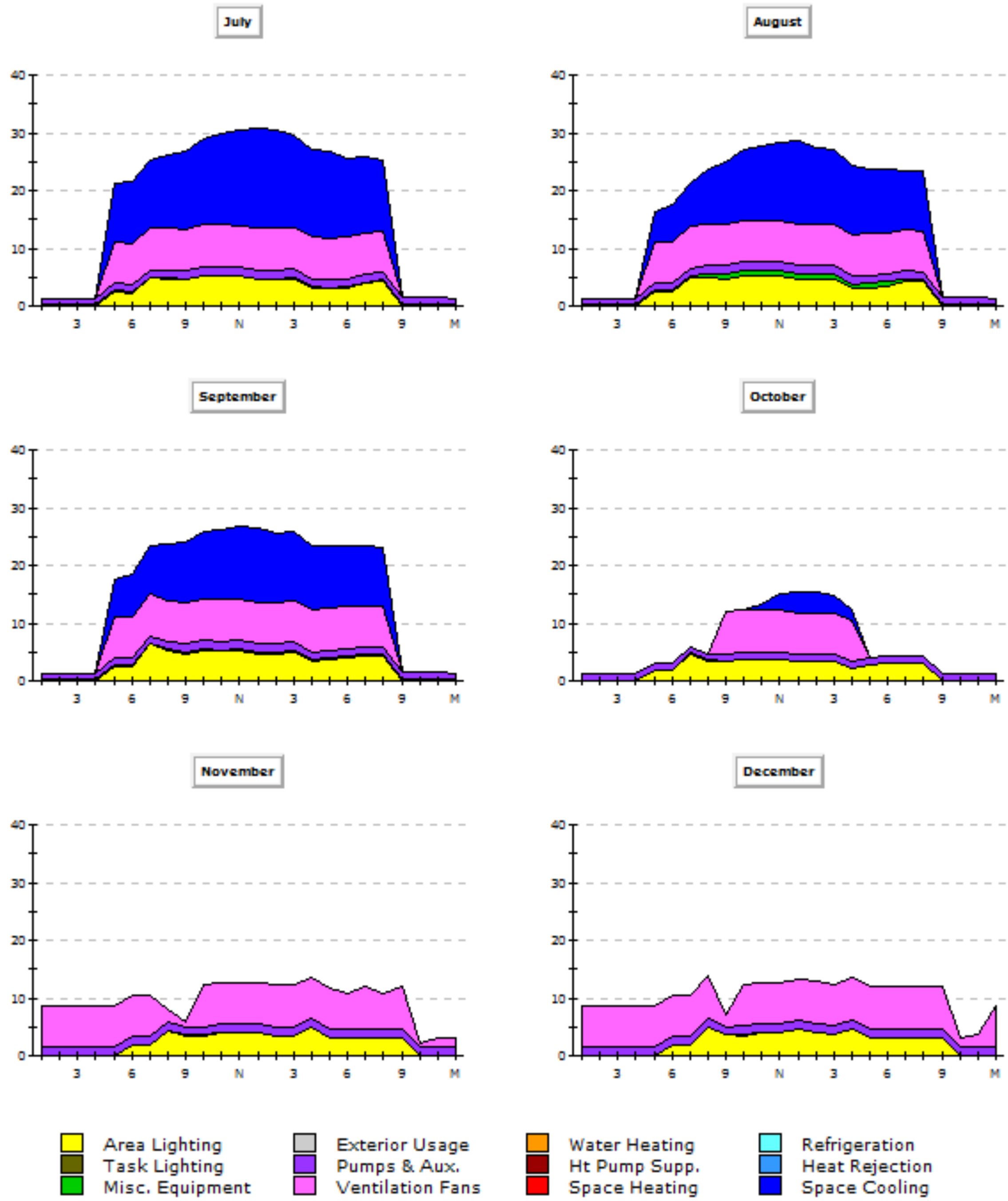


Figure 61 eQuest Improved Design Monthly Electric Peak Day Load Profiles Results

Month	Solar Radiation (kWh/m2/day)	AC Energy (kWh)	Energy Value ($)
January	2.59	2811	430.93
Febuary	3.48	3344	512.64
March	4.32	4441	680.81
April	5.13	4900	751.17
May	5.45	5287	810.50
June	5.72	5238	802.99
July	5.94	5508	844.38
August	5.31	4886	749.02
September	4.96	4539	695.83
October	3.94	3887	595.88
November	2.72	2684	411.46
December	2.47	2596	397.97
Annual	4.34	50121	7683.55

Figure 62 Main Bathhouse (Oceanside) Solar Panels Energy Value

Month	Solar Radiation (kWh/m2/day)	AC Energy (kWh)	Energy Value ($)
January	1.87	980	150.23
Febuary	2.73	1285	196.99
March	3.73	1904	291.88
April	4.77	2272	348.30
May	5.33	2573	394.44
June	5.7	2595	397.81
July	5.84	2693	412.84
August	5.02	2299	352.44
September	4.35	1982	303.84
October	3.18	1550	237.62
November	2.01	961	147.32
December	1.69	849	130.15
Annual	3.85	21943	3363.86

Figure 63 Dining Area (Facing East) Solar Panels Energy Value

Month	Solar Radiation (kWh/m2/day)	AC Energy (kWh)	Energy Value ($)
January	1.9	991	151.92
Febuary	2.77	1304	199.90
March	3.6	1826	279.93
April	4.89	2318	355.35
May	5.33	2570	393.98
June	5.85	2658	407.47
July	5.83	2687	411.92
August	5.1	2334	357.80
September	4.48	2036	312.12
October	3.08	1487	227.96
November	1.99	950	145.64
December	1.7	851	130.46
Annual	3.88	22012	3374.44

Figure 64 Dining Area (Facing West) Solar Panels Energy Value

Appendix B Proposed Grade Beam and Slab Design

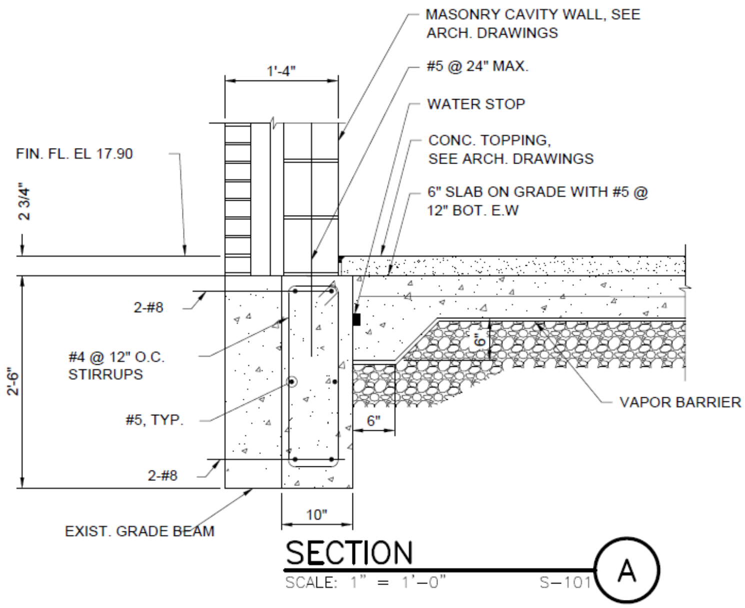


Figure 65 Section (A) 10" Grade Beam-Proposed Design

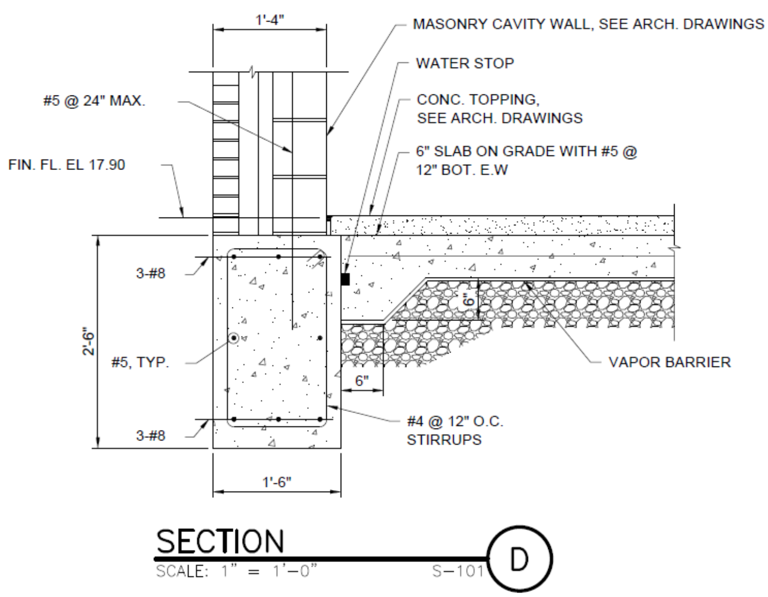


Figure 66 Section (D) 18" Grade Beam-Proposed Design

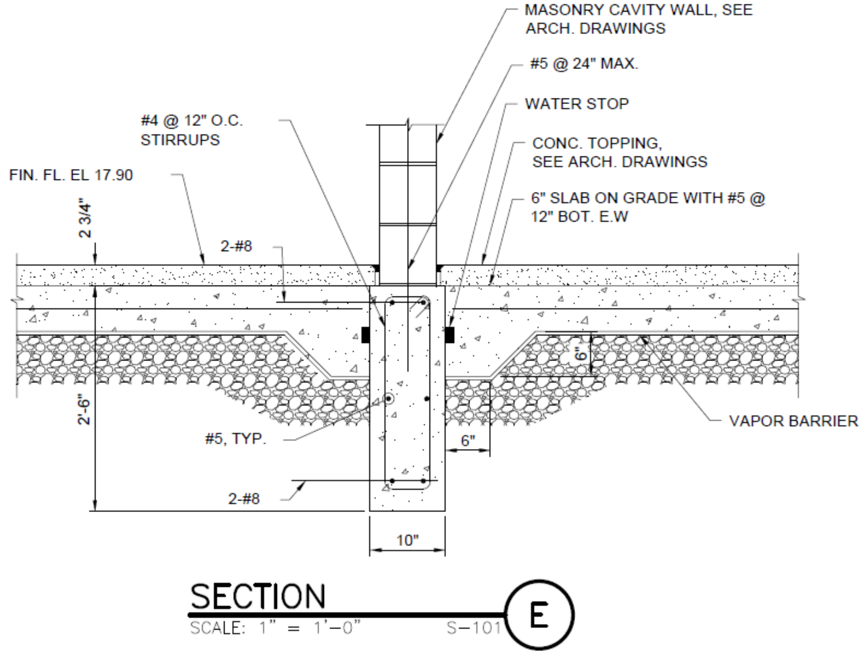


Figure 67 Section (E) 10" Grade Beam for Interior Load Bearing Walls-Proposed Design

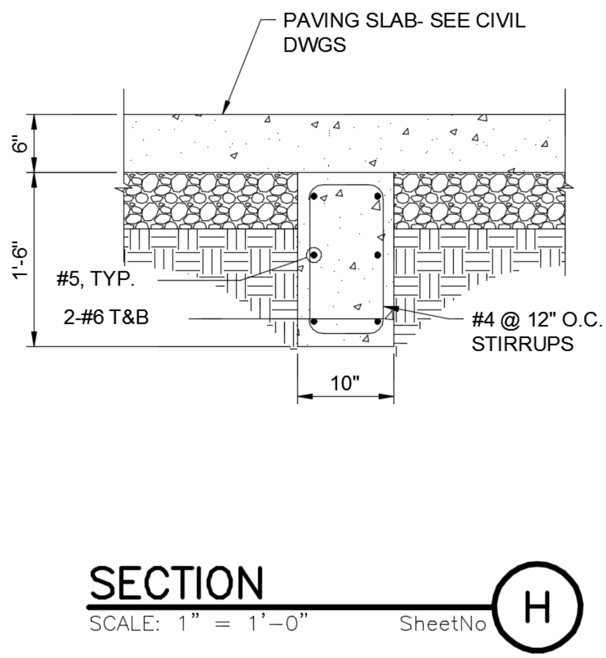
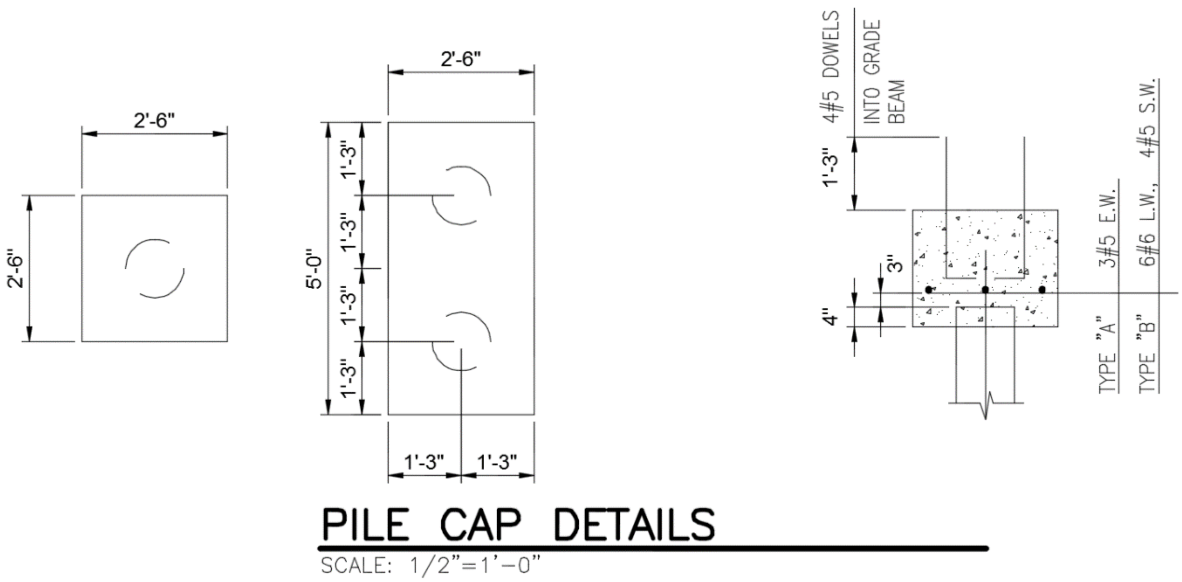


Figure 68 Section (H) 10" Grade Beam for Portico-Proposed Design

Appendix C Proposed Pile Cap Design



In addition to the pile cap, the design proposed by Stantec calls for additional piles. The piles are specified to be 12" diameter timber piles which are designed to act as friction piles. They are specified to be 40 feet in length.

Appendix D Roof Design

The roof design and analysis was performed using Autodesk Robot Structural Analysis 2016. The method of input for the software is detailed in the Robot Structural Analysis section in Appendix D.

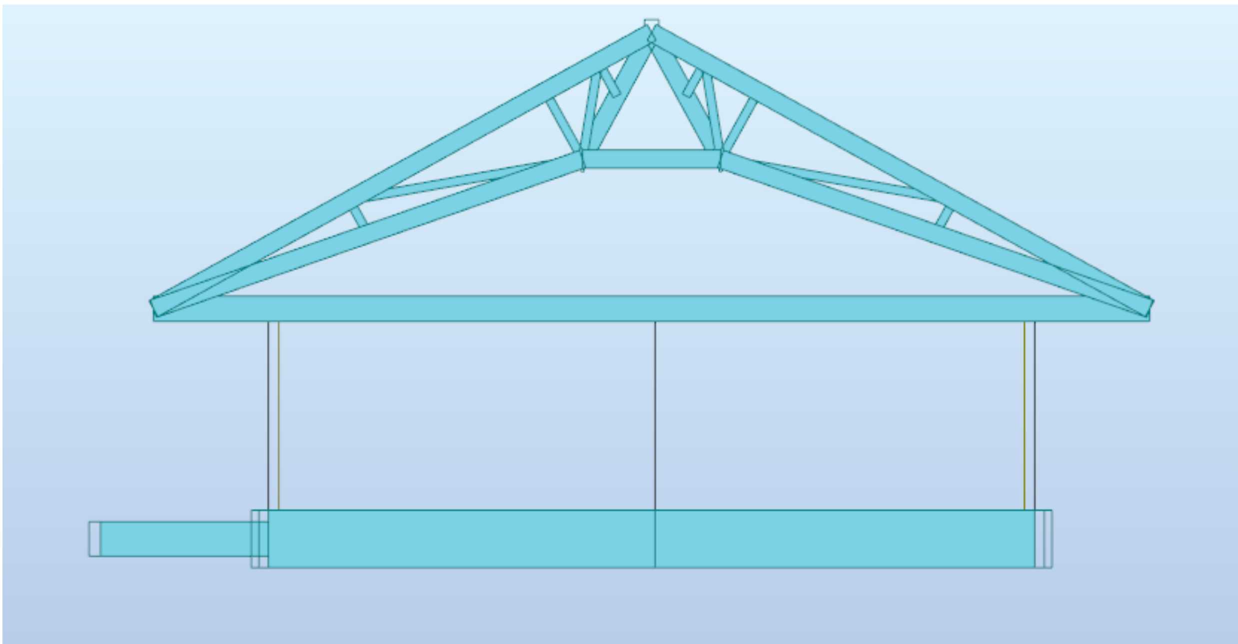


Figure 69 Truss Design Layout

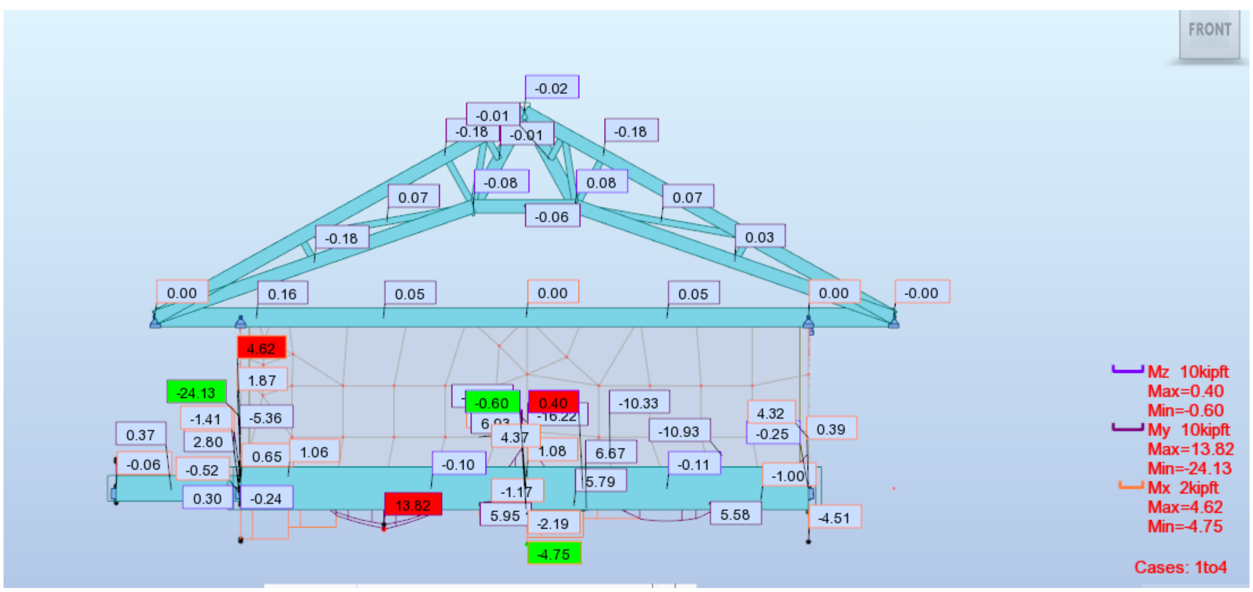


Figure 70 Moment analysis for proposed truss design

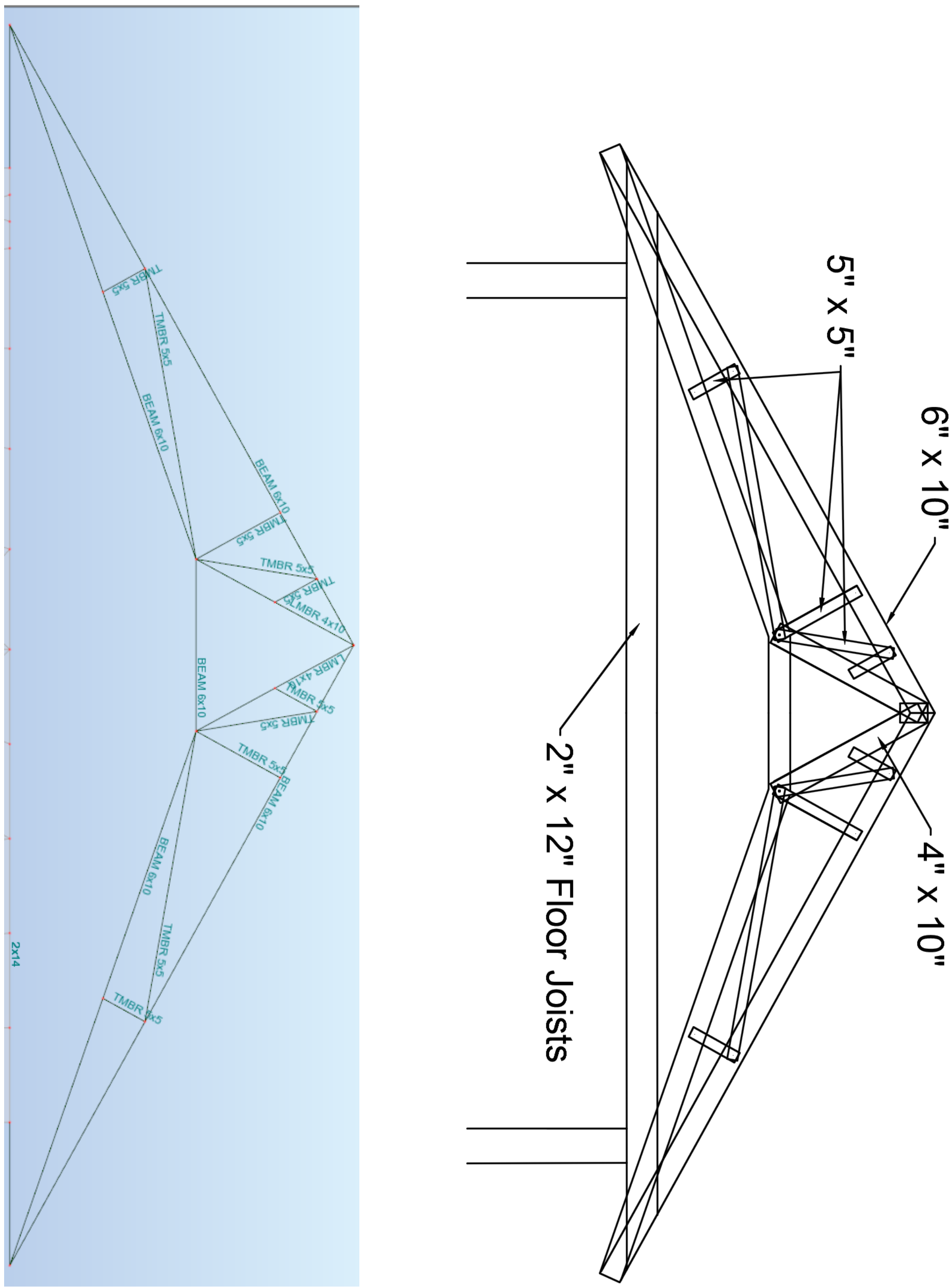


Figure 71 Member size for truss design. On the left is the Robot Structural Analysis output and on the right is an AutoCad drawing based on the analysis results.

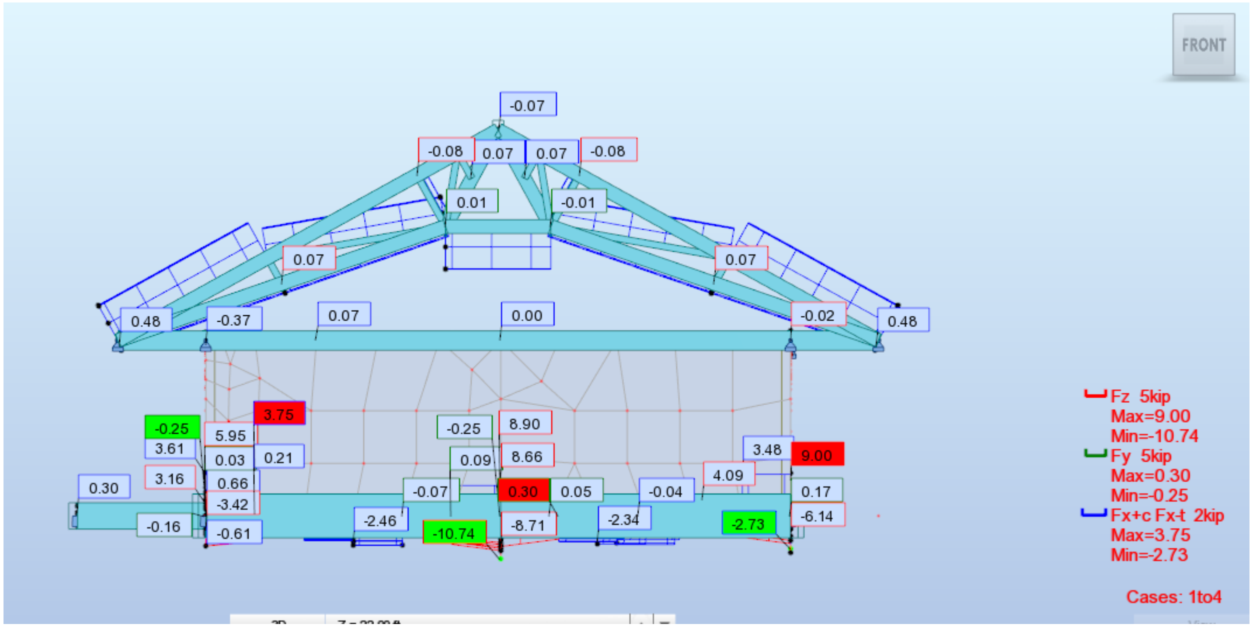


Figure 72 Reaction forces analysis for truss design

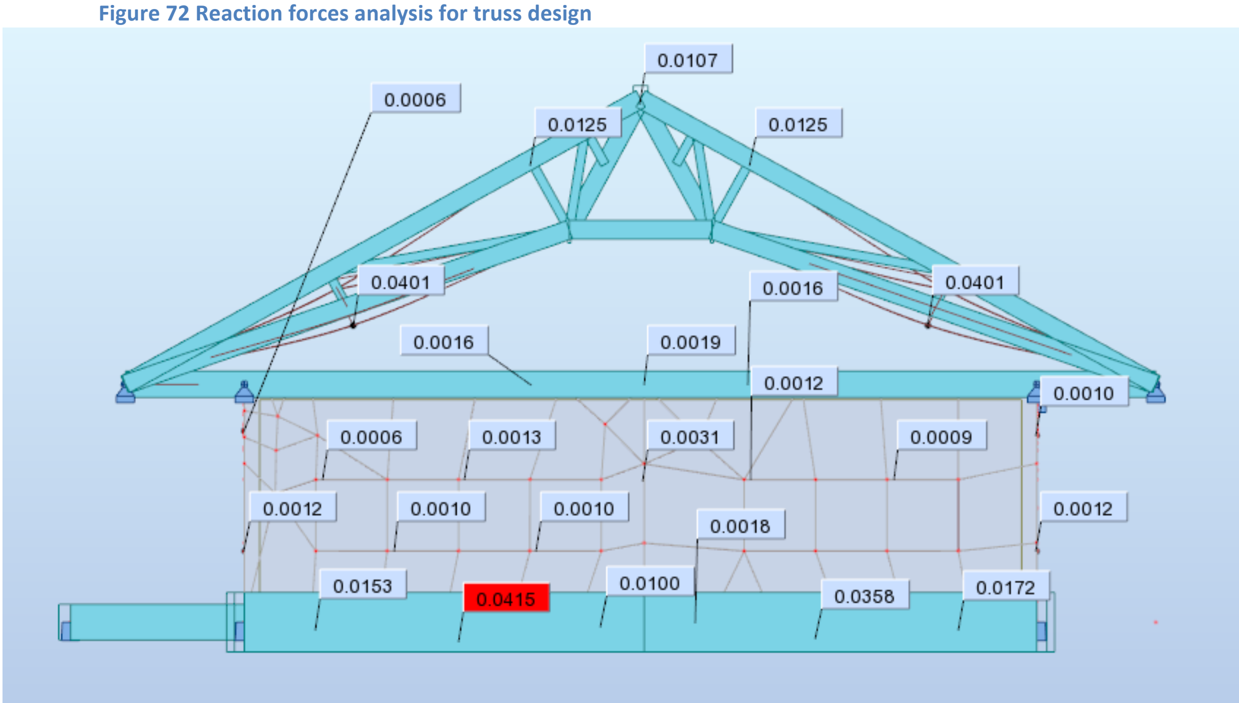


Figure 73 Deflections (in inches) for truss design

ANSI/AWC NDS-2012 LRFD - Member Verification (SLS ; ULS) 11 50 65to71 104to108 204to1475 1477

Results | Messages

Member		Section	Material	Lay	Laz	Ratio	Case	Ratio(uy	Case (uy)	Ratio(uz	Case (uz)
11 Beam_11	!	2x14	ALASKA CED	228.23	2016.00	14.70	1 DL1	0.00	1 DL1	0.00	1 DL1
50 Beam_50	!	2x14	ALASKA CED	228.23	2016.00	4.30	1 DL1	0.00	1 DL1	0.00	1 DL1
65	OK	BEAM 6x10	SOUTHERN PI	24.95	43.09	0.02	2 LL1	0.02	2 LL1	0.02	2 LL1
66	OK	LMBR 4x10	SOUTHERN PI	8.13	21.48	0.01	2 LL1	-	-	-	-
67	OK	BEAM 6x10	SOUTHERN PI	31.27	54.01	0.02	2 LL1	0.00	2 LL1	0.01	2 LL1
68	OK	BEAM 6x10	SOUTHERN PI	24.95	43.09	0.02	2 LL1	0.02	2 LL1	0.02	2 LL1
69	OK	LMBR 4x10	SOUTHERN PI	8.13	21.48	0.01	2 LL1	-	-	-	-
70	OK	BEAM 6x10	SOUTHERN PI	31.27	54.01	0.02	2 LL1	0.00	2 LL1	0.01	2 LL1
71	OK	BEAM 6x10	SOUTHERN PI	7.58	13.09	0.00	2 LL1	0.01	2 LL1	0.00	1 DL1
104	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.02	2 LL1	-	-	-	-
105	OK	TMBR 5x5	SOUTHERN PI	8.95	8.95	0.03	2 LL1	-	-	-	-
106	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.00	2 LL1	-	-	-	-
107	OK	TMBR 5x5	SOUTHERN PI	27.45	27.45	0.02	1 DL1	-	-	-	-
108	OK	TMBR 5x5	SOUTHERN PI	11.40	11.40	0.01	2 LL1	-	-	-	-
204	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.02	2 LL1	-	-	-	-
205	OK	TMBR 5x5	SOUTHERN PI	8.95	8.95	0.03	2 LL1	-	-	-	-
206	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.00	2 LL1	-	-	-	-
207	OK	TMBR 5x5	SOUTHERN PI	27.45	27.45	0.02	1 DL1	-	-	-	-
208	OK	TMBR 5x5	SOUTHERN PI	11.40	11.40	0.01	2 LL1	-	-	-	-
209	OK	BEAM 6x10	SOUTHERN PI	24.95	43.09	0.02	2 LL1	0.00	2 LL1	0.04	2 LL1
210	OK	LMBR 4x10	SOUTHERN PI	8.13	21.48	0.00	2 LL1	-	-	-	-
211	OK	BEAM 6x10	SOUTHERN PI	31.27	54.01	0.03	2 LL1	0.00	2 LL1	0.03	2 LL1
212	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.00	1 DL1	-	-	-	-
213	OK	TMBR 5x5	SOUTHERN PI	8.95	8.95	0.00	2 LL1	-	-	-	-
214	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.00	2 LL1	-	-	-	-
215	OK	TMBR 5x5	SOUTHERN PI	27.45	27.45	0.02	1 DL1	-	-	-	-
216	OK	TMBR 5x5	SOUTHERN PI	11.40	11.40	0.00	2 LL1	-	-	-	-
217	OK	BEAM 6x10	SOUTHERN PI	24.95	43.09	0.02	2 LL1	0.00	2 LL1	0.04	2 LL1
218	OK	LMBR 4x10	SOUTHERN PI	8.13	21.48	0.00	2 LL1	-	-	-	-
219	OK	BEAM 6x10	SOUTHERN PI	31.27	54.01	0.03	2 LL1	0.00	2 LL1	0.03	2 LL1
220	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.00	1 DL1	-	-	-	-
221	OK	TMBR 5x5	SOUTHERN PI	8.95	8.95	0.00	2 LL1	-	-	-	-
222	OK	TMBR 5x5	SOUTHERN PI	4.47	4.47	0.00	2 LL1	-	-	-	-
223	OK	TMBR 5x5	SOUTHERN PI	27.45	27.45	0.02	1 DL1	-	-	-	-
224	OK	TMBR 5x5	SOUTHERN PI	11.40	11.40	0.00	2 LL1	-	-	-	-
225	OK	BEAM 6x10	SOUTHERN PI	7.58	13.09	0.00	1 DL1	0.00	2 LL1	0.00	1 DL1

Calc. Note | Close | Help

Ratio: Analysis | Map

Calculation points
Division: n = 3
Extremes: none
Additional: none

Figure 74 Example of typical beam analysis

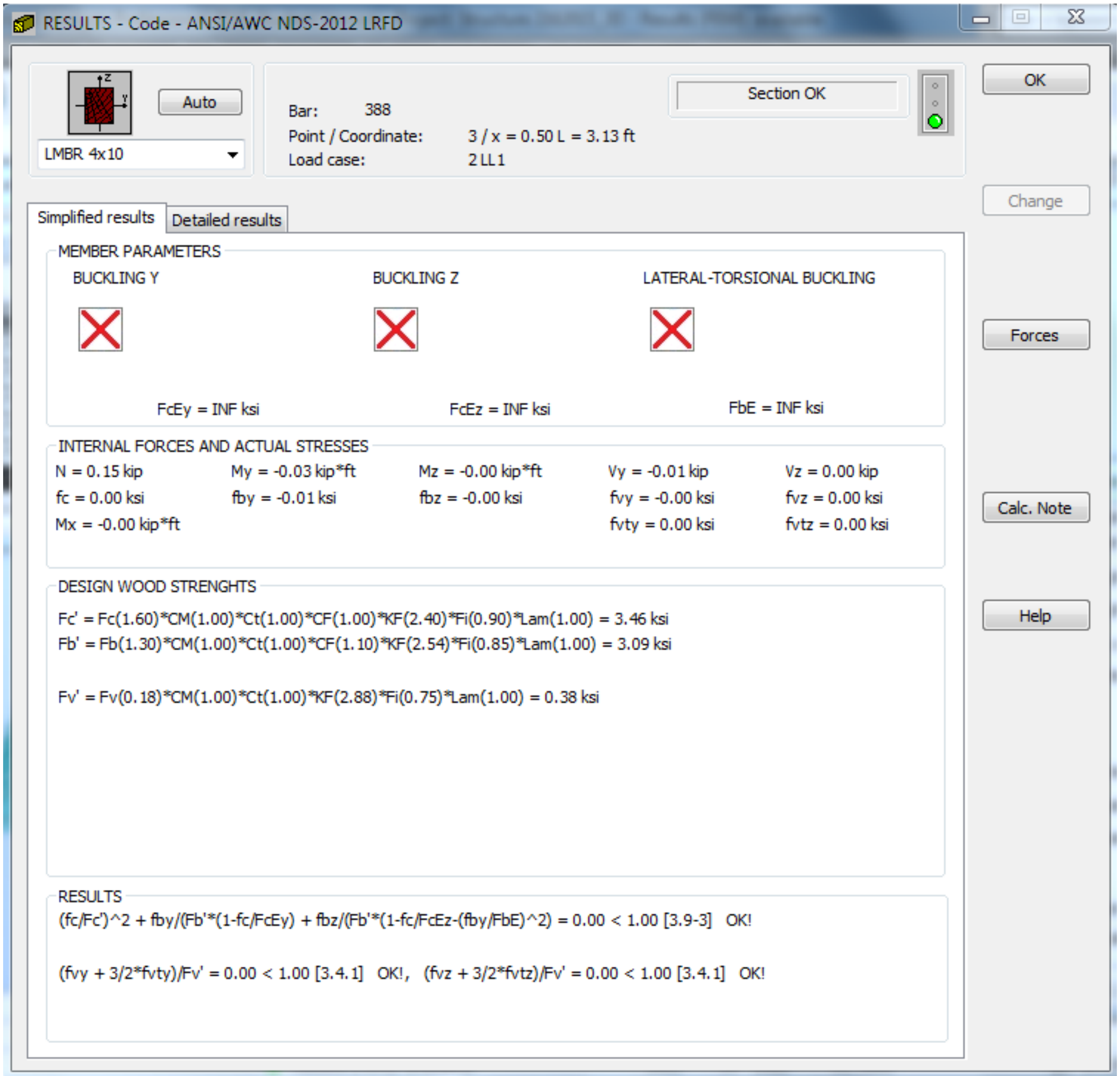


Figure 75 Example of simplified results for beam analysis

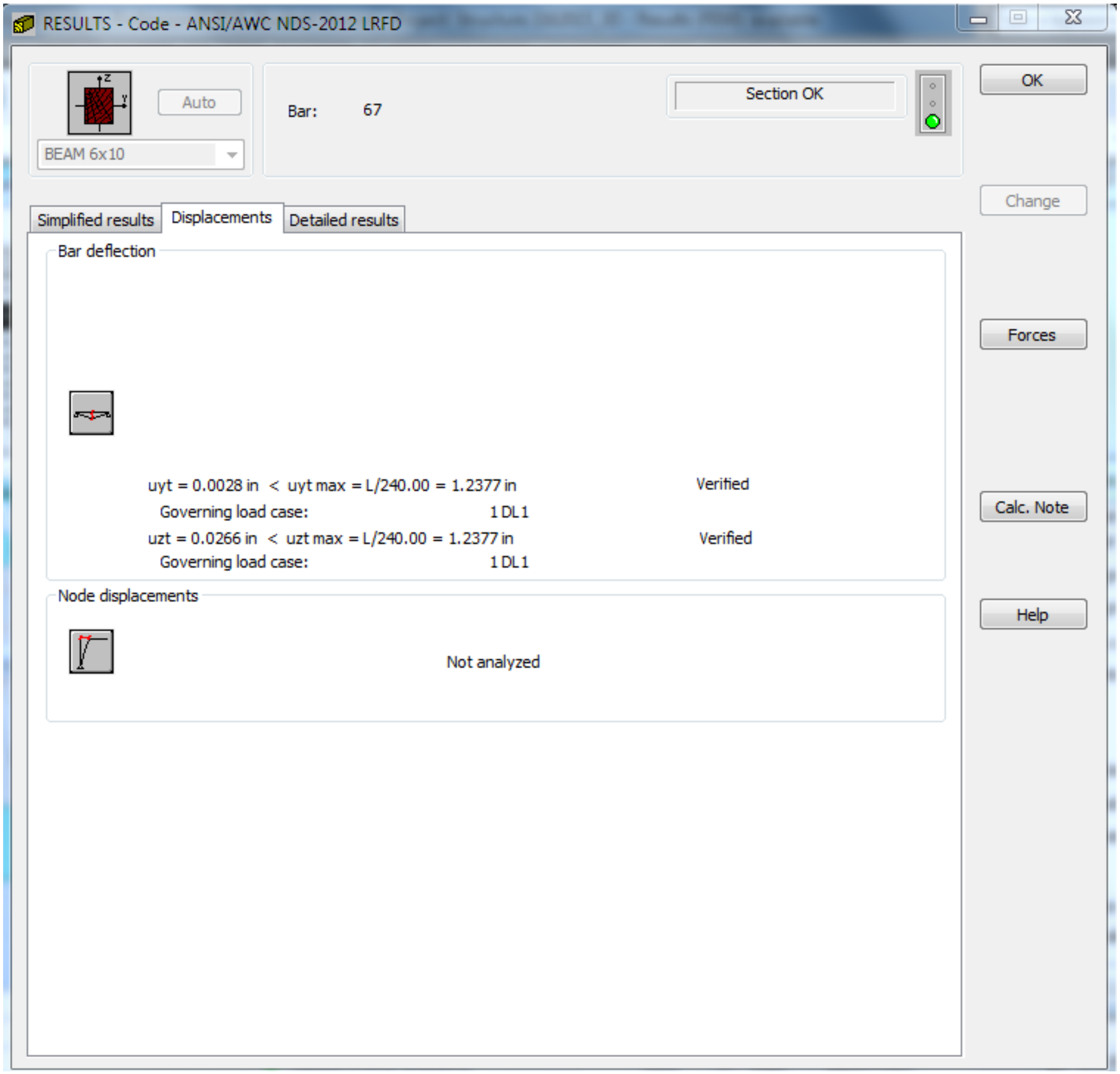


Figure 76 Example of displacements for beam analysis

Appendix E Robot Structural Analysis

Microsoft Excel was used to increases the efficiency of creating the structural model. The structural software used was Autodesk Robot Structural Analysis (RSA). For a full building model of this size, modeling the individual nodes and members becomes tedious. Utilizing the function features in excel expedites the process by determining the location of the nodes, members, and member properties in a spreadsheet and then importing the spreadsheet into Robot Structural Analysis. For the structural modeling of the Field 5 bathhouse, the roof nodes were spaced at regular intervals (16”), so the corresponding excel file allowed every member to be input using the “fill” feature. Each node was 16” from the last, and the nodes were then copied to a separate spreadsheet that matched the nodes to the members. The requirements of importing the Excel file consist of ensuring the rows and columns match that of the Robot Structural Analysis spreadsheets. Additionally, any named sections, materials, sizes, etc. must contain the same syntax as that which is used in Robot Structural Analysis. For example, 2x4 and 2 x 4 are not equivalent due to different spacing, and one will return an error or be copied into the spreadsheet as a blank cell.

299	109		WOOD	Southern Pine	Timber Beam	Beam				
300	110		WOOD	Southern Pine	Timber Beam	Beam				
301	111		WOOD	Southern Pine	Timber Beam	Beam				
302	112		WOOD	Southern Pine	Timber Beam	Beam				
303	113		WOOD	Southern Pine	Timber Beam	Beam				
304	114		WOOD	Southern Pine	Timber Beam	Beam				
305	115		WOOD	Southern Pine	Timber Beam	Beam				
306	116		WOOD	Southern Pine	Timber Beam	Beam				
307	117		WOOD	Southern Pine	Timber Beam	Beam				
308	118		WOOD	Southern Pine	Timber Beam	Beam				
309	119		WOOD	Southern Pine	Timber Beam	Beam				
310	120		WOOD	Southern Pine	Timber Beam	Beam				
311	121		WOOD	Southern Pine	Timber Beam	Beam				
312	122		WOOD	Southern Pine	Timber Beam	Beam				
313	123		WOOD	Southern Pine	Timber Beam	Beam				
314	124		WOOD	Southern Pine	Timber Beam	Beam				
315	125		WOOD	Southern Pine	Timber Beam	Beam				
316	126		WOOD	Southern Pine	Timber Beam	Beam				
317	127		WOOD	Southern Pine	Timber Beam	Beam				
318	128		WOOD	Southern Pine	Timber Beam	Beam				
319	129		WOOD	Southern Pine	Timber Beam	Beam				
320	130		WOOD	Southern Pine	Timber Beam	Beam				
321	131		WOOD	Southern Pine	Timber Beam	Beam				
322	132		WOOD	Southern Pine	Timber Beam	Beam				
323	133		WOOD	Southern Pine	Timber Beam	Beam				
324	134		WOOD	Southern Pine	Timber Beam	Beam				
325	135		WOOD	Southern Pine	Timber Beam	Beam				
326	136		WOOD	Southern Pine	Timber Beam	Beam				
327	137		WOOD	Southern Pine	Timber Beam	Beam				
328	138		WOOD	Southern Pine	Timber Beam	Beam				
329	139		WOOD	Southern Pine	Timber Beam	Beam				
330	140		WOOD	Southern Pine	Timber Beam	Beam				
331	141		WOOD	Southern Pine	Timber Beam	Beam				
332	142		WOOD	Southern Pine	Timber Beam	Beam				
333	143		WOOD	Southern Pine	Timber Beam	Beam				
334	144		WOOD	Southern Pine	Timber Beam	Beam				
335	145		WOOD	Southern Pine	Timber Beam	Beam				
336	146		WOOD	Southern Pine	Timber Beam	Beam				
337	147		WOOD	Southern Pine	Timber Beam	Beam				
338	148		WOOD	Southern Pine	Timber Beam	Beam				
339	149		WOOD	Southern Pine	Timber Beam	Beam				
340	150		WOOD	Southern Pine	Timber Beam	Beam				
341	151		WOOD	Southern Pine	Timber Beam	Beam				
342	152		WOOD	Southern Pine	Timber Beam	Beam				
343	153		WOOD	Southern Pine	Timber Beam	Beam				
344	154		WOOD	Southern Pine	Timber Beam	Beam				
345	155		WOOD	Southern Pine	Timber Beam	Beam				

Figure 77 Example of Excel spreadsheet to import members into RSA

Bar	Node 1	Node 2	Section	Material	Gamma (Deg)	Type	Structure object
1433	4264	4266	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1434	4264	4268	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1435	4256	4264	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1436	485	4270	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1437	4270	4272	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Beam
1438	485	4272	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1439	4269	4273	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1440	4270	4274	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1441	4271	4275	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1442	4270	4273	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1443	4270	4275	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1444	675	4278	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1445	4278	4272	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Bar
1446	675	4272	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1447	4277	4280	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1448	4278	4281	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1449	4279	4282	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1450	4278	4280	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1451	4278	4282	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1452	4270	4278	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1453	488	4284	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1454	4284	4286	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Beam
1455	488	4286	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1456	4283	4287	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1457	4284	4288	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1458	4285	4289	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1459	4284	4287	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1460	4284	4289	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1461	678	4292	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1462	4292	4286	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Bar
1463	678	4286	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1464	4291	4294	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1465	4292	4295	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar

Bar	Node 1	Node 2	Section	Material	Gamma (Deg)	Type	Structure object
1433	4264	4266	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1434	4264	4268	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1435	4256	4264	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1436	485	4270	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1437	4270	4272	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Beam
1438	485	4272	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1439	4269	4273	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1440	4270	4274	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1441	4271	4275	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1442	4270	4273	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1443	4270	4275	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1444	675	4278	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1445	4278	4272	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Bar
1446	675	4272	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1447	4277	4280	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1448	4278	4281	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1449	4279	4282	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1450	4278	4280	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1451	4278	4282	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1452	4270	4278	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1453	488	4284	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1454	4284	4286	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Beam
1455	488	4286	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1456	4283	4287	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1457	4284	4288	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1458	4285	4289	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1459	4284	4287	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1460	4284	4289	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1461	678	4292	BEAM 6x1	*SOUTHERN*	180.0	Timber Beam	Beam
1462	4292	4286	LMBR 4x1	*SOUTHERN*	0.0	Timber Member	Bar
1463	678	4286	BEAM 6x1	*SOUTHERN*	0.0	Timber Beam	Beam
1464	4291	4294	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar
1465	4292	4295	TMBR 5x5	*SOUTHERN*	0.0	Timber Member	Bar

Figure 78 Spreadsheet in RSA, allowing direct input or importing from Excel

Appendix F Slab Design

Slab Design

Mu		k-ft	**L**	16	ft	**As**		in^2
fc'	4	ksi	**w**	16	ft	**A's**		in^2
fy	60	ksi	**d'**	0.75	in	**n**		
Est	29000		**d**		in	β	0.85	
DL	0.12	k/ft				**λ**	1	
LL	0.1	k/ft						
P	0	k (mid)						

❶ Assume Slab Thickness

	L/20=	8	in
Assume	d=	7	in

❷ Calculate factored Load

Weight of Slab

$\frac{h}{12}(150) =$ 100 psf

0.1 kpf

Wu=1.2D+1.6L 0.424 ksf

For 1ft Sectionof Slab

$Mu = \frac{W_u L^2}{8}$ 7.632 k-ft

❸ Calculate As

Mu	b	d
7.632	12	7

$R_u = \frac{M_u}{bd^2}$ 155.7551 psi

$\rho_b = 0.85\beta\left(\frac{f'_c}{f_y}\right)[\frac{87}{(87+f_y}]$ 0.028506803

$\rho_{max} = (0.003 + \frac{f_y}{E_s})\frac{\rho_b}{0.008}$ 0.0180625

0.004 **<---use this value**

$A_s = \rho bd$ 0.336 in^2

Choose #5 0.31 0.31 in^2

S= 11.07142857 in

❹ Check Moment Capacity

$a = \frac{A_s f_y}{0.85 f'_c b}$ 0.455882353 in

$\varphi M_n = \varphi A_s f_y (d - \frac{a}{2})$ 113.3642647 k-in

9.447022059 k-ft **OK**

❺ Calculate Secondary (shrinkage) Reinforcement

$A_{sh} = \rho bh$		0.1728	in^2
Choose #4	0.2	0.2	in^2
S=		13.88888889	in^2

❻ Check Shear

vu	1.06	K	
$\varphi V_c = \varphi 2\lambda\sqrt{f'_c}bd$	7.968939704	K	
$\frac{1}{2}\varphi V_c =$	3.984469852	K	**OK**

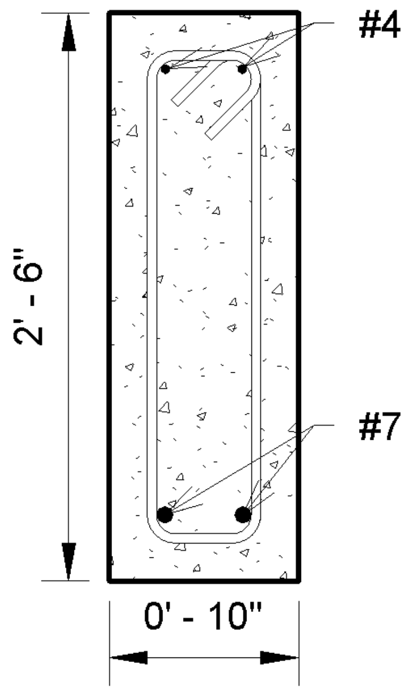
$A_{sh} = \rho bh$		0.1728	in^2	
Choose #4	0.2	0.2	in^2	
S=		13.88888889	in^2	

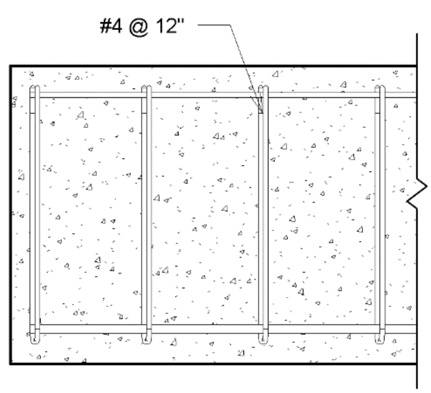
❻ Check Shear

vu	1.06	K	
$\varphi V_c = \varphi 2\lambda\sqrt{f'_c}bd$	7.968939704	K	
$\frac{1}{2}\varphi V_c =$	3.984469852	K	**OK**

Appendix G Alternate Beam Design Calculations (1)

10" x 30" Beam





Singly Reinforced Beam

10 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft		b	10	in
f'c	4000	psi		h	30	in
fy	60000	psi		d	26.5	in
				d'	3.5	in

Area of Steel Rough Estimate

Mu/4d 1.137791 in^2

1. Calculate ρ

$\rho = \frac{Mu}{f'_c * bd^2}$ 0.051523

2. Determine ω

$\rho = \omega(0.9 - 0.5294\omega)$ 0.059317

3. Reinforcement Ratio

$\rho = \omega \frac{f'_c}{f_y}$ 0.003954

4. Minimum Reinforcement

$\rho = MAX(\frac{3\sqrt{f'_c}}{f_y}, \frac{200}{f_y})$ 0.003333

5. Calculate β1

$$\beta 1 = \begin{cases} 0.85 \text{ if f'c<4000} \\ 0.85 - \frac{f'_c - 4{,}000}{20{,}000} \text{ if f'c > 4000} \\ 0.65 \text{ if f'c > 8000} \end{cases}$$

β1= 0.85

6. Maximum Reinforcement

$\rho_{max} = 0.364\beta_1 \frac{f'_c}{f_y}$ 0.020627

7. Required Reinforcement

$\rho_{req} = MIN[MAX(\rho, \rho_{min}), \rho_{max}]$ 0.003954

8. Tension Controlled Ratio

$\rho_t = .319\beta_1 \frac{f'_c}{f_y}$ 0.018077

9. Controlled State

$\rho_{req} < \rho_t ?$ Tension Controlled

10. Required Area of Steel

$A_{s,req} = \rho_{req} A$ 1.047934 in^2

Choose Reinforcements

As	2#7	1.2	in^2

11. Compression Block

$a = \frac{A_s f_y}{.85 f'_c b}$ 2.117647059 in

12. Location of Neutal Axis

$c = \frac{a}{\beta_1}$ 2.491349481 in

13. Φ Factor

$\Phi = MAX(\left(0.23 + \frac{.25}{\frac{c}{d}}\right), 0.65)$ 2.889201

14. Revised Reinforcement

$A_{s,req(c)} = A_{s,req}(\frac{0.9}{\phi})$ 0.326436 in^2

Shear

10 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft	b	10	in	d	26.5
fc'	4	ksi	h	30	in	dt	27
fy	60	ksi	d'bottom	3.5	in	d'top	3
Est	29000		β	0.85		L	18
DL	2.052633		λ	1		Lsupport	12
LL	2.41425						

1. Calculate Factored Shear

$w = 1.2D + 1.6L$ 6.325959

$V_u = \frac{wL}{2}$ 56.93363

$Design\ V_u = V_u - d\frac{w}{L_{support}}$ 42.9638 k

$\Phi V_c = \Phi(2\lambda\sqrt{f'_c})b_w d$ 25.14011 k

$\frac{1}{2}\Phi V_c =$ 12.57005 k

Calculate Shear Reinforcement

$V_s = (V_u - \Phi V_c)/\Phi$ 42.39136 k

$V_{c1} = 4\sqrt{f'_c})b_w d$ 67.04029 k

$V_{c2} = 8\sqrt{f'_c})b_w d$ 134.0806 k

Proceed in the Design

2. Stirrup Spacing Av= 0.4 #3 0.22

$S_1 = A_v f_{yt} d / V_s$ 15.00306 #4 0.4

Maximum Spacing

$S_2 = \frac{d}{2} \leq 24in\ if\ V_s \leq V_{c1}$ 13.25

$S_2 = \frac{d}{4} \leq 12in\ if\ V_{c1} < V_s \leq V_{c2}$

$S_3 = \frac{A_v f_{yt}}{50 b_w} \geq A_v f_{yt}/(0.75\sqrt{f'_c} b_w)$ 48

Max Spacing= 13.25 in

3. Distance at Which No Shear Reinforcement is Needed

$x' = \frac{V_u - \frac{1}{2}V_c}{V_u}(8)$ 6.233725 ft
74.8047 inches

Development Length

10 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft	**b**	10	in	Ψt	1		
fc'	4	ksi	**h**	30	in	Ψe	1		
fy	60	ksi	**d'bottom**	3.5	in				
Est	29000		**λ**	1					

1. In Tension

Number 7 Bars and Larger db 0.875

$$\frac{l_d}{d_b} = \left(\frac{f_y}{\sqrt{f'_c}}\right)\frac{\Psi_t \Psi_e}{20\lambda}$$ 41.50489 in

Number 6 Bars and Smaller db 0.5

$$\frac{l_d}{d_b} = \left(\frac{f_y}{\sqrt{f'_c}}\right)\frac{\Psi_t \Psi_e}{25\lambda}$$ 18.97367 in

2. In Compression db 0.5

$$l_{dc} = \frac{0.02 d_b f_y}{\lambda\sqrt{f'_c}} \geq 0.0003 d_b f_y$$ 9.486833 >= 9

Deflection and Cracking

10 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	200	k-ft	b	10	in	As	1.2	in^2
fc'	4	ksi	h	30	in	A's	0.4	in^2
fy	60	ksi	d'	3.5	in	n	8	
Est	29000		d	26.5	in	β	0.85	
DL	2.052633	k/ft	L	18	ft			
LL	2.41425	k/ft						
P	0	k (mid)						

1. Minimum Thickness of Beams/One Way Slabs

ACI Table 9.5(a) L/16 13.5 in **Deflection OK**

2. Modulus of Elasticity of Concrete

$E_c = 57{,}400\sqrt{f'_c}$ 3630295 psi

3. Deflection at Midspan Due to Distributed Load

❶ $\Delta_1 = \frac{5wL^4}{384E_cI_e}$ .... 0.538718 in

❷ $I_e = (\frac{M_{cr}}{M_a})^3 I_g + [1-(\frac{M_{cr}}{M_a})^3]I_{cr} \leq I_g$ .... 5394.776 in^4

❸ $M_a = \frac{wL^2}{8} + \frac{PL}{4}$ .... 2170.905 k-in

❹ $I_g = \frac{bh^3}{12}$ .... 22500 in^4

❺ $M_{cr} = \frac{f_r I_g}{Y_t}$ .... 711.5125 k-in

❻ $Y_t = \frac{h}{2}$ .... 15 in

❼ $f_r = 7.5\lambda\sqrt{f'_c}$ .... 474.3416 psi

❽ $I_{cr} = \frac{b}{3}x^3 + (n-1)A'_s(x-d')^2 + nA_s(d-x)^2$ .... 4770.582 in^4

Determine Neutral Axis

❾ $b\frac{x^2}{2} + (n-1)A'_s(x-d') - nA_s(d-x) = 0$ 6.134117 in

$\Delta_2 = \frac{PL^2}{48E_cI_e}$ 0 in

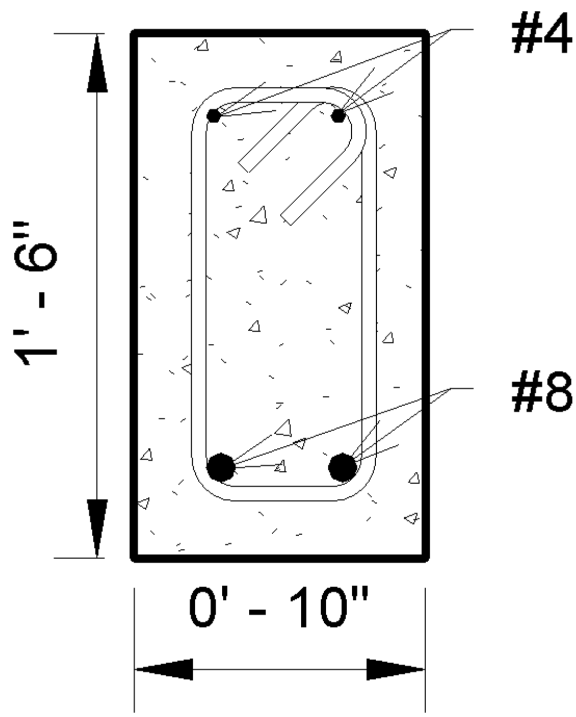
4. Total Immediate Deflection

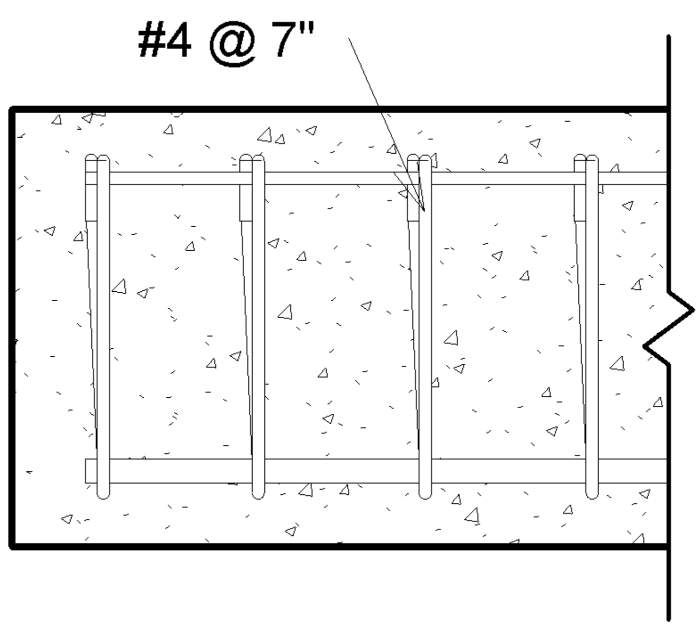
$\Delta_1 + \Delta_2 =$ 0.538718 in

5. Allowable Deflection

L/360 0.6 **Beam Passes**

10” x 18” Beam





Singly Reinforced Beam

10 Inch Grade Beam (Portico)
Assumption: Simply Supported

Mu	90.45437 k-ft		b	10	in
f'c	4000 psi		h	18	in
fy	60000 psi		d	14.5	in
			d'	3.5	in

Area of Steel Rough Estimate
Mu/4d 1.559558 in^2

1. Calculate ρ

$$\rho = \frac{Mu}{f'_c * bd^2}$$

0.129067

2. Determine ω

$$\rho = \omega(0.9 - 0.5294\omega)$$

0.158113

3. Reinforcement Ratio

$$\rho = \omega \frac{f'_c}{f_y}$$

0.010541

4. Minimum Reinforcement

$$\rho = MAX\left(\frac{3\sqrt{f'_c}}{f_y}, \frac{200}{f_y}\right)$$

0.003333

5. Calculate β1

β1= 0.85 if f'c<4000

$0.85 - \frac{f'_c - 4{,}000}{20{,}000}$ if f'c > 4000

0.65 if f'c > 8000

β1= 0.85

6. Maximum Reinforcement

$$\rho_{max} = 0.364\beta_1 \frac{f'_c}{f_y}$$

0.020627

7. Required Reinforcement

$$\rho_{req} = MIN[MAX(\rho, \rho_{min}), \rho_{max}]$$

0.010541

8. Tension Controlled Ratio

$$\rho_t = .319\beta_1 \frac{f'_c}{f_y}$$

0.018077

9. Controlled State

$\rho_{req} < \rho_t?$

Tension Controlled

10. Required Area of Steel

$A_{s,req} = \rho_{req} A$

1.528426 in^2

Choose Reinforcements

As	2#8	1.58	in^2

11. Compression Block

$a = \frac{A_s f_y}{.85 f'_c b}$ 2.788235294 in

12. Location of Neutal Axis

$c = \frac{a}{\beta_1}$ 3.280276817 in

13. Φ Factor

$\Phi = MAX(\left(0.23 + \frac{.25}{\frac{c}{d}}\right), 0.65)$ 1.33509

14. Revised Reinforcement

$A_{s,req(c)} = A_{s,req}(\frac{0.9}{\phi})$ 1.03033 in^2

Shear

10 Inch Grade Beam (Portico)
Assumption: Simply Supported

Mu	90.45437	k-ft	**b**	10	in	d	14.5	
fc'	4	ksi	**h**	18	in	dt	15	
fy	60	ksi	**d'bottom**	3.5	in	**d'top**	3	
Est	29000		β	0.85		L	16	
DL	0.8		**λ**	1		**Lsupport**	12	in
LL	0.8							

1. Calculate Factored Shear

$w = 1.2D + 1.6L$	2.24	
$V_u = \frac{wL}{2}$	17.92	
$Design\ V_u = V_u - d\frac{w}{L_{support}}$	15.21333	k
$\Phi V_c = \Phi(2\lambda\sqrt{f'_c})b_w d$	13.75591	k
$\frac{1}{2}\Phi V_c =$	6.877954	k

Calculate Shear Reinforcement

$V_s = (V_u - \Phi V_c)/\Phi$	5.552123	k
$V_{c1} = 4\sqrt{f'_c})b_w d$	36.68242	k
$V_{c2} = 8\sqrt{f'_c})b_w d$	73.36484	k

Proceed in the Design

2. Stirrup Spacing	Av=	0.4	#3	0.22
$S_1 = A_v f_{yt} d/V_s$		62.67873	#4	0.4

Maximum Spacing

$S_2 = \frac{d}{2} \leq 24in\ if\ V_s \leq V_{c1}$	7.25
$S_2 = \frac{d}{4} \leq 12in\ if\ V_{c1} < V_s \leq V_{c2}$	
$S_3 = \frac{A_v f_{yt}}{50 b_w} \geq A_v f_{yt}/(0.75\sqrt{f'_c} b_w)$	48

Max Spacing= 7.25 in

3. Distance at Which No Shear Reinforcement is Needed

$$x' = \frac{V_u - \frac{1}{2}V_c}{V_u}(8)$$

4.929485 ft
59.15382 inches

Development Length

10 Inch Grade Beam (Portico)
Assumption: Simply Supported

Mu	90.45437	k-ft	**b**	10	in	Ψt	1	
fc'	4	ksi	**h**	18	in	Ψe	1	
fy	60	ksi	**d'bottom**	3.5	in			
Est	29000		**λ**	1				

1. In Tension

Number 7 Bars and Larger db 1

$$\frac{l_d}{d_b} = (\frac{f_y}{\sqrt{f'_c}})\frac{\Psi_t\Psi_e}{20\lambda}$$

47.43416 in

Number 6 Bars and Smaller db 0.5

$$\frac{l_d}{d_b} = (\frac{f_y}{\sqrt{f'_c}})\frac{\Psi_t\Psi_e}{25\lambda}$$

18.97367 in

2. In Compression db 0.5

$$l_{dc} = \frac{0.02 d_b f_y}{\lambda\sqrt{f'_c}} \geq 0.0003 d_b f_y$$

9.486833 >= 9

Deflection and Cracking

10 Inch Grade Beam (Portico)
Assumption: Simply Supported

Mu	200	k-ft	b	10	in	As	1.58	in^2
fc'	4	ksi	h	18	in	A's	0.4	in^2
fy	60	ksi	d'	3.5	in	n	8	
Est	29000		d	14.5	in	β	0.85	
DL	1.026316	k/ft	L	16	ft			
LL	0.9	k/ft						
P	0	k (mid)						

1. Minimum Thickness of Beams/One Way Slabs

ACI Table 9.5(a) L/16 12 in **Deflection OK**

2. Modulus of Elasticity of Concrete

$E_c = 57{,}400\sqrt{f'_c}$ 3630295 psi

3. Deflection at Midspan Due to Distributed Load

❶ $\Delta_1 = \frac{5wL^4}{384E_cI_e}$ .... 0.460427 in

❷ $I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + [1 - (\frac{M_{cr}}{M_a})^3]I_{cr} \leq I_g$ .... 1699.368 in^4

❸ $M_a = \frac{wL^2}{8} + \frac{PL}{4}$ .... 739.7054 k-in

❹ $I_g = \frac{bh^3}{12}$ .... 4860 in^4

❺ $M_{cr} = \frac{f_r I_g}{Y_t}$ .... 256.1445 k-in

❻ $Y_t = \frac{h}{2}$ .... 9 in

❼ $f_r = 7.5\lambda\sqrt{f'_c}$ .... 474.3416 psi

❽ $I_{cr} = \frac{b}{3}x^3 + (n-1)A'_s(x-d')^2 + nA_s(d-x)^2$ .... 1562.446 in^4

Determine Neutral Axis

❾ $b\frac{x^2}{2} + (n-1)A'_s(x-d') - nA_s(d-x) = 0$ 4.859119 in

$\Delta_2 = \frac{PL^2}{48E_cI_e}$ 0 in

4. Total Immediate Deflection

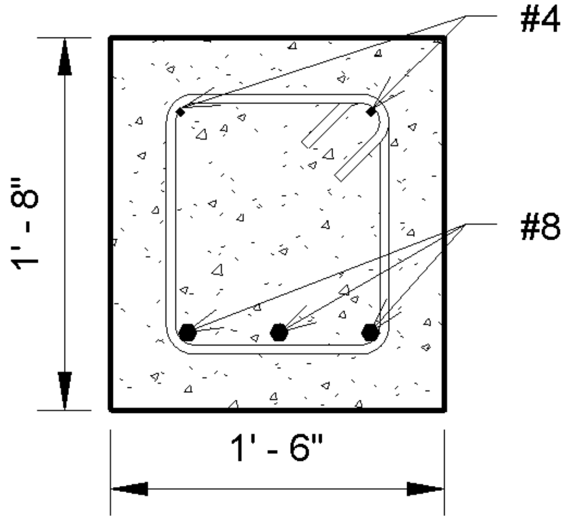
$\Delta_1 + \Delta_2 =$ 0.460427 in

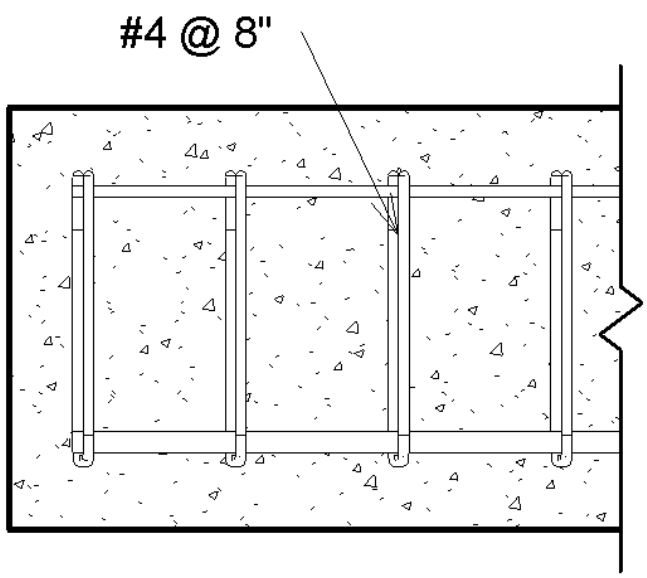
5. Allowable Deflection

L/360 0.533333 **Beam Passes**

Appendix H Alternate Beam Design Calculations (2)

18" x 20" Beam





Singly Reinforced Beam

18x20 Inch Grade Beam
Assumption: Simply Supported

Mu	120.6058 k-ft		b	18	in
f'c	4000 psi		h	20	in
fy	60000 psi		d	16.5	in
			d'	3.5	in

Area of Steel Rough Estimate
Mu/4d 1.827361 in^2

1. Calculate ρ

$\rho = \frac{Mu}{f'c * bd^2}$ 0.073833

2. Determine ω

$\rho = \omega(0.9 - 0.5294\omega)$ 0.086431

3. Reinforcement Ratio

$\rho = \omega\frac{f'_c}{f_y}$ 0.005762

4. Minimum Reinforcement

$\rho = MAX(\frac{3\sqrt{f'c}}{fy}, \frac{200}{fy})$ 0.003333

5. Calculate β1

β1= { 0.85 if f'c<4000; $0.85 - \frac{f'c - 4,000}{20,000}$ if f'c > 4000; 0.65 if f'c > 8000 }

β1= 0.85

6. Maximum Reinforcement

$\rho_{max} = 0.364\beta_1\frac{f'_c}{f_y}$ 0.020627

7. Required Reinforcement

$\rho_{req} = MIN[MAX(\rho, \rho_{min}), \rho_{max}]$ 0.005762

8. Tension Controlled Ratio

$\rho_t = .319\beta_1\frac{f'_c}{f_y}$ 0.018077

9. Controlled State

$\rho_{req} < \rho_t?$ Tension Controlled

10. Required Area of Steel

$A_{s,req} = \rho_{req}A$ 1.711325 in^2

Choose Reinforcements

As	3#8	2.37	in^2

11. Compression Block

$a = \frac{A_s f_y}{.85 f'_c b}$ 2.323529412 in

12. Location of Neutal Axis

$c = \frac{a}{\beta_1}$ 2.733564014 in

13. Φ Factor

$\Phi = MAX(\left(0.23 + \frac{.25}{\frac{c}{d}}\right), 0.65)$ 1.739019

14. Revised Reinforcement

$A_{s,req(c)} = A_{s,req}(\frac{0.9}{\phi})$ 0.885668 in^2

Shear

18x20 Inch Grade Beam
Assumption: Simply Supported

Mu	120.6058	k-ft	b	18	in	d	16.5	
fc'	4	ksi	h	20	in	dt	17	
fy	60	ksi	d'bottom	3.5	in	d'top	3	
Est	29000		β	0.85		L	16	
DL	2.052633		λ	1		Lsupport	12	in
LL	2.41425							

1. Calculate Factored Shear

$w = 1.2D + 1.6L$ — 6.325959

$V_u = \frac{wL}{2}$ — 50.60767

$Design\ V_u = V_u - d\frac{w}{L_{support}}$ — 41.90948 k

$\Phi V_c = \Phi(2\lambda\sqrt{f'_c})b_w d$ — 28.17589 k

$\frac{1}{2}\Phi V_c =$ — 14.08795 k

Calculate Shear Reinforcement

$V_s = (V_u - \Phi V_c)/\Phi$ — 29.90904 k

$V_{c1} = 4\sqrt{f'_c})b_w d$ — 75.13572 k

$V_{c2} = 8\sqrt{f'_c})b_w d$ — 150.2714 k

Proceed in the Design

2. Stirrup Spacing Av= 0.4 — #3 0.22

$S_1 = A_v f_{yt} d/V_s$ — 13.24015 — #4 0.4

Maximum Spacing

$S_2 = \frac{d}{2} \leq 24in\ if\ V_s \leq V_{c1}$ — 8.25

$S_2 = \frac{d}{4} \leq 12in\ if\ V_{c1} < V_s \leq V_{c2}$

$S_3 = \frac{A_v f_{yt}}{50 b_w} \geq A_v f_{yt}/(0.75\sqrt{f'_c} b_w)$ — 26.66667

Max Spacing= 8.25 in

3. Distance at Which No Shear Reinforcement is Needed

$x' = \frac{V_u - \frac{1}{2}V_c}{V_u}(8)$ — 5.772994 ft
69.27593 inches

Development Length

18x20 Inch Grade Beam
Assumption: Simply Supported

Mu	120.6058	k-ft	**b**	18	in	Ψt	1
fc'	4	ksi	**h**	20	in	Ψe	1
fy	60	ksi	**d'bottom**	3.5	in		
Est	29000		**λ**	1			

1. In Tension

Number 7 Bars and Larger db 1

$$\frac{l_d}{d_b} = \left(\frac{f_y}{\sqrt{f'_c}}\right)\frac{\Psi_t\Psi_e}{20\lambda}$$

47.43416 in

Number 6 Bars and Smaller db 0.5

$$\frac{l_d}{d_b} = \left(\frac{f_y}{\sqrt{f'_c}}\right)\frac{\Psi_t\Psi_e}{25\lambda}$$

18.97367 in

2. In Compression db 0.5

$$l_{dc} = \frac{0.02 d_b f_y}{\lambda\sqrt{f'_c}} \geq 0.0003 d_b f_y$$

9.486833 >= 9

Deflection and Cracking

18x20 Inch Grade Beam
Assumption: Simply Supported

Mu	200 k-ft	b	18 in	As	2.37	in^2
fc'	4 ksi	h	20 in	A's	0.4	in^2
fy	60 ksi	d'	3.5 in	n	8	
Est	29000	d	16.5 in	β	0.85	
DL	2.052633 k/ft	L	16 ft			
LL	2.41425 k/ft					
P	0 k (mid)					

1. Minimum Thickness of Beams/One Way Slabs

ACI Table 9.5(a) L/16 12 in **Deflection OK**

2. Modulus of Elasticity of Concrete

$E_c = 57{,}400\sqrt{f'_c}$ 3630295 psi

3. Deflection at Midspan Due to Distributed Load

❶ $\Delta_1 = \dfrac{5wL^4}{384E_cI_e}$ 0.506533 in

❷ $I_e = \left(\dfrac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\dfrac{M_{cr}}{M_a}\right)^3\right] I_{cr} \le I_g$ 3581.933 in^4

❸ $M_a = \dfrac{wL^2}{8} + \dfrac{PL}{4}$ 1715.283 k-in

❹ $I_g = \dfrac{bh^3}{12}$ 12000 in^4

❺ $M_{cr} = \dfrac{f_r I_g}{Y_t}$ 569.21 k-in

❻ $Y_t = \dfrac{h}{2}$ 10 in

❼ $f_r = 7.5\lambda\sqrt{f'_c}$ 474.3416 psi

❽ $I_{cr} = \dfrac{b}{3}x^3 + (n-1)A'_s(x-d')^2 + nA_s(d-x)^2$ 3262.64 in^4

Determine Neutral Axis

❾ $b\dfrac{x^2}{2} + (n-1)A'_s(x-d') - nA_s(d-x) = 0$ 4.899327 in

$\Delta_2 = \dfrac{PL^2}{48E_cI_e}$ 0 in

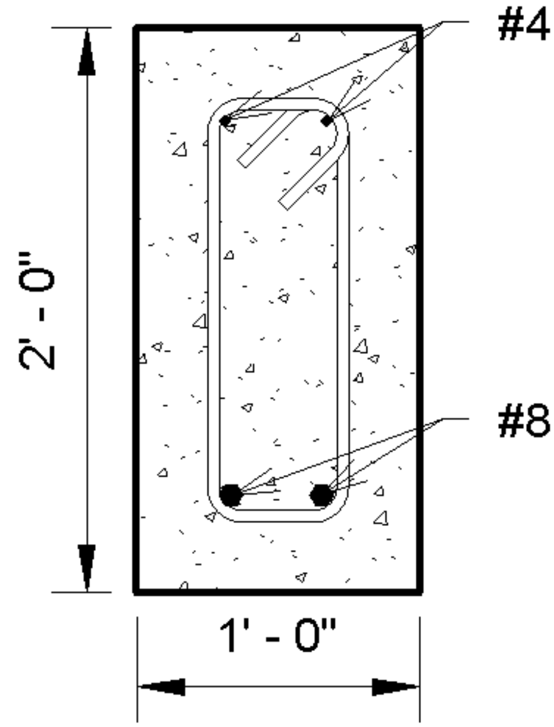
4. Total Immediate Deflection

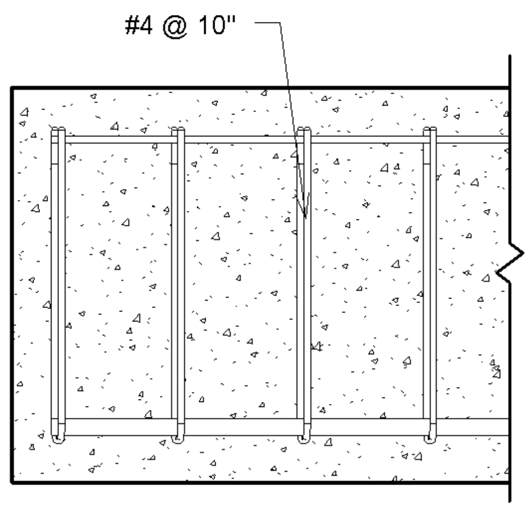
$\Delta_1 + \Delta_2 =$ 0.506533 in

5. Allowable Deflection

L/360 0.533333 **Beam Passes**

12” x 24” Beam





Singly Reinforced Beam

12 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058 k-ft		b	12	in
f'c	4000 psi		h	24	in
fy	60000 psi		d	20.5	in
			d'	3.5	in

Area of Steel Rough Estimate

Mu/4d 1.470803 in^2

1. Calculate ρ

$$\rho = \frac{Mu}{f'_c * bd^2}$$

0.071746

2. Determine ω

$$\rho = \omega(0.9 - 0.5294\omega)$$

0.083854

3. Reinforcement Ratio

$$\rho = \omega\frac{f'_c}{f_y}$$

0.00559

4. Minimum Reinforcement

$$\rho = MAX(\frac{3\sqrt{f'_c}}{f_y}, \frac{200}{f_y})$$

0.003333

5. Calculate β1

β1= { 0.85 if f'c<4000; $0.85 - \frac{f'_c - 4{,}000}{20{,}000}$ if f'c > 4000; 0.65 if f'c > 8000 }

β1= 0.85

6. Maximum Reinforcement

$$\rho_{max} = 0.364\beta_1\frac{f'_c}{f_y}$$

0.020627

7. Required Reinforcement

$$\rho_{req} = MIN[MAX(\rho, \rho_{min}), \rho_{max}]$$

0.00559

8. Tension Controlled Ratio

$$\rho_t = .319\beta_1\frac{f'_c}{f_y}$$

0.018077

9. Controlled State

$\rho_{req} < \rho_t ?$ Tension Controlled

10. Required Area of Steel

$A_{s,req} = \rho_{req} A$ 1.375213 in^2

Choose Reinforcements

As	2#8	1.58	in^2

11. Compression Block

$a = \frac{A_s f_y}{.85 f'_c b}$ 2.323529412 in

12. Location of Neutal Axis

$c = \frac{a}{\beta_1}$ 2.733564014 in

13. Φ Factor

$\Phi = MAX(\left(0.23 + \frac{.25}{\frac{c}{d}}\right), 0.65)$ 2.104842

14. Revised Reinforcement

$A_{s,req(c)} = A_{s,req}(\frac{0.9}{\phi})$ 0.588021 in^2

Shear

12 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft	b	12	in	d	20.5	
fc'	4	ksi	h	24	in	dt	21.5	
fy	60	ksi	d'bottom	3.5	in	d'top	2.5	
Est	29000		β	0.85		L	16	
DL	2.052633		λ	1		Lsupport	12	in
LL	2.41425							

1. Calculate Factored Shear

$w = 1.2D + 1.6L$ — 6.325959

$V_u = \frac{wL}{2}$ — 50.60767

$Design\ V_u = V_u - d\frac{w}{L_{support}}$ — 39.80083 k

$\Phi V_c = \Phi(2\lambda\sqrt{f'_c})b_w d$ — 23.33761 k

$\frac{1}{2}\Phi V_c =$ — 11.6688 k

Calculate Shear Reinforcement

$V_s = (V_u - \Phi V_c)/\Phi$ — 36.36008 k

$V_{c1} = 4\sqrt{f'_c})b_w d$ — 62.23362 k

$V_{c2} = 8\sqrt{f'_c})b_w d$ — 124.4672 k

Proceed in the Design

2. Stirrup Spacing Av= 0.4 — #3 0.22

$S_1 = A_v f_{yt} d/V_s$ — 13.53132 — #4 0.4

Maximum Spacing

$S_2 = \frac{d}{2} \leq 24in\ if\ V_s \leq V_{c1}$ — 10.25

$S_2 = \frac{d}{4} \leq 12in\ if\ V_{c1} < V_s \leq V_{c2}$

$S_3 = \frac{A_v f_{yt}}{50 b_w} \geq A_v f_{yt}/(0.75\sqrt{f'_c}b_w)$ — 40

Max Spacing= 10.25 in

3. Distance at Which No Shear Reinforcement is Needed

$x' = \frac{V_u - \frac{1}{2}V_c}{V_u}(8)$ — 6.155409 ft

73.86491 inches

Development Length

12 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft	**b**	12	in	Ψt		1
fc'	4	ksi	**h**	24	in	Ψe		1
fy	60	ksi	**d'bottom**	3.5	in			
Est	29000		**λ**	1				

1. In Tension

Number 7 Bars and Larger db 1

$$\frac{l_d}{d_b} = \left(\frac{f_y}{\sqrt{f'_c}}\right)\frac{\Psi_t \Psi_e}{20\lambda}$$

47.43416 in

Number 6 Bars and Smaller db 0.5

$$\frac{l_d}{d_b} = \left(\frac{f_y}{\sqrt{f'_c}}\right)\frac{\Psi_t \Psi_e}{25\lambda}$$

18.97367 in

2. In Compression db 0.5

$$l_{dc} = \frac{0.02 d_b f_y}{\lambda\sqrt{f'_c}} \geq 0.0003 d_b f_y$$

9.486833 >= 9

Deflection and Cracking

12 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	200	k-ft	b	12	in	As	1.58	in^2
fc'	4	ksi	h	24	in	A's	0.4	in^2
fy	60	ksi	d'	3.5	in	n	8	
Est	29000		d	20	in	β	0.85	
DL	2.052633	k/ft	L	16	ft			
LL	2.41425	k/ft						
P	0	k (mid)						

1. Minimum Thickness of Beams/One Way Slabs

ACI Table 9.5(a) L/16 12 in **Deflection OK**

2. Modulus of Elasticity of Concrete

$E_c = 57{,}400\sqrt{f'_c}$ 3630295 psi

3. Deflection at Midspan Due to Distributed Load

❶ $\Delta_1 = \dfrac{5wL^4}{384E_cI_e}$ .... 0.493943 in

❷ $I_e = \left(\dfrac{M_{cr}}{M_a}\right)^3 I_g + [1-(\dfrac{M_{cr}}{M_a})^3]I_{cr} \le I_g$ .... 3673.234 in^4

❸ $M_a = \dfrac{wL^2}{8} + \dfrac{PL}{4}$ .... 1715.283 k-in

❹ $I_g = \dfrac{bh^3}{12}$ .... 13824 in^4

❺ $M_{cr} = \dfrac{f_r I_g}{Y_t}$ .... 546.4416 k-in

❻ $Y_t = \dfrac{h}{2}$ .... 12 in

❼ $f_r = 7.5\lambda\sqrt{f'_c}$ .... 474.3416 psi

❽ $I_{cr} = \dfrac{b}{3}x^3 + (n-1)A'_s(x-d')^2 + nA_s(d-x)^2$ .... 3334.08 in^4

Determine Neutral Axis

❾ $b\dfrac{x^2}{2} + (n-1)A'_s(x-d') - nA_s(d-x) = 0$ 5.452931 in

$\Delta_2 = \dfrac{PL^2}{48E_cI_e}$ 0 in

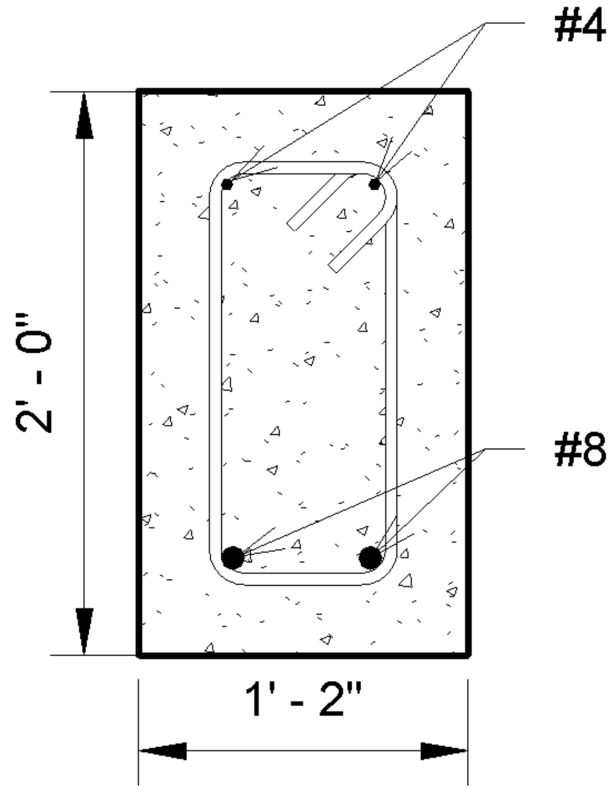
4. Total Immediate Deflection

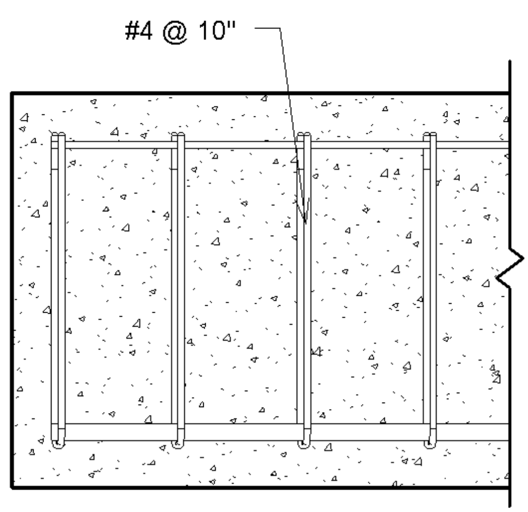
$\Delta_1 + \Delta_2 =$ 0.493943 in

5. Allowable Deflection

L/360 0.533333 **Beam Passes**

14" x 24" Beam





Singly Reinforced Beam

14 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058 k-ft		b	14	in
f'c	4000 psi		h	24	in
fy	60000 psi		d	20.5	in
			d'	3.5	in

Area of Steel Rough Estimate

Mu/4d 1.470803 in^2

1. Calculate ρ

$\rho = \frac{Mu}{f'_c * bd^2}$ 0.061497

2. Determine ω

$\rho = \omega(0.9 - 0.5294\omega)$ 0.071322

3. Reinforcement Ratio

$\rho = \omega\frac{f'_c}{f_y}$ 0.004755

4. Minimum Reinforcement

$\rho = MAX(\frac{3\sqrt{f'_c}}{f_y}, \frac{200}{f_y})$ 0.003333

5. Calculate β1

β1= 0.85 if f'c<4000

$0.85 - \frac{f'_c - 4,000}{20,000}$ if f'c > 4000

0.65 if f'c > 8000

β1= 0.85

6. Maximum Reinforcement

$\rho_{max} = 0.364\beta_1\frac{f'_c}{f_y}$ 0.020627

7. Required Reinforcement

$\rho_{req} = MIN[MAX(\rho, \rho_{min}), \rho_{max}]$ 0.004755

8. Tension Controlled Ratio

$\rho_t = .319\beta_1\frac{f'_c}{f_y}$ 0.018077

9. Controlled State

$\rho_{req} < \rho_t?$ | Tension Controlled

10. Required Area of Steel

$A_{s,req} = \rho_{req} A$ | 1.364631 in^2

Choose Reinforcements

As	2#8	1.58	in^2

11. Compression Block

$a = \frac{A_s f_y}{.85 f'_c b}$ 1.991596639 in

12. Location of Neutal Axis

$c = \frac{a}{\beta_1}$ 2.343054869 in

13. Φ Factor

$\Phi = MAX(\left(0.23 + \frac{.25}{\frac{c}{d}}\right), 0.65)$ 2.417315

14. Revised Reinforcement

$A_{s,req(c)} = A_{s,req}(\frac{0.9}{\phi})$ 0.508071 in^2

Shear

14 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft	b	14	in	d	20.5	
fc'	4	ksi	h	24	in	dt	21.5	
fy	60	ksi	d'bottom	3.5	in	d'top	2.5	
Est	29000		β	0.85		L	16	
DL	2.052633		λ	1		Lsupport	12	in
LL	2.41425							

1. Calculate Factored Shear

$w = 1.2D + 1.6L$ — 6.325959

$V_u = \frac{wL}{2}$ — 50.60767

$Design\ V_u = V_u - d\frac{w}{L_{support}}$ — 39.80083 k

$\Phi V_c = \Phi(2\lambda\sqrt{f'_c})b_w d$ — 27.22721 k

$\frac{1}{2}\Phi V_c =$ — 13.61361 k

Calculate Shear Reinforcement

$V_s = (V_u - \Phi V_c)/\Phi$ — 31.17395 k

$V_{c1} = 4\sqrt{f'_c})b_w d$ — 72.6059 k

$V_{c2} = 8\sqrt{f'_c})b_w d$ — 145.2118 k

Proceed in the Design

2. Stirrup Spacing Av= 0.4 — #3 0.22

$S_1 = A_v f_{yt} d / V_s$ — 15.78241 — #4 0.4

Maximum Spacing

$S_2 = \frac{d}{2} \leq 24in\ if\ V_s \leq V_{c1}$ — 10.25

$S_2 = \frac{d}{4} \leq 12in\ if\ V_{c1} < V_s \leq V_{c2}$

$S_3 = \frac{A_v f_{yt}}{50 b_w} \geq A_v f_{yt}/(0.75\sqrt{f'_c} b_w)$ — 34.28571

Max Spacing= 10.25 in

3. Distance at Which No Shear Reinforcement is Needed

$x' = \frac{V_u - \frac{1}{2}V_c}{V_u}(8)$ — 5.847978 ft

70.17573 inches

Development Length

14 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	120.6058	k-ft	**b**	14	in	Ψt	1
fc'	4	ksi	**h**	24	in	Ψe	1
fy	60	ksi	**d'bottom**	3.5	in		
Est	29000		**λ**	1			

1. In Tension

Number 7 Bars and Larger db 1

$$\frac{l_d}{d_b} = (\frac{f_y}{\sqrt{f'_c}})\frac{\Psi_t\Psi_e}{20\lambda}$$

47.43416 in

Number 6 Bars and Smaller db 0.5

$$\frac{l_d}{d_b} = (\frac{f_y}{\sqrt{f'_c}})\frac{\Psi_t\Psi_e}{25\lambda}$$

18.97367 in

2. In Compression db 0.5

$$l_{dc} = \frac{0.02 d_b f_y}{\lambda\sqrt{f'_c}} \geq 0.0003 d_b f_y$$

9.486833 >= 9

Deflection and Cracking

12 Inch Grade Beam (Along Exterior Wall)
Assumption: Simply Supported

Mu	200	k-ft	**b**	14	in	**As**	1.58 in^2
fc'	4	ksi	**h**	24	in	**A's**	0.4 in^2
fy	60	ksi	**d'**	3.5	in	**n**	8
Est	29000		**d**	20	in	**β**	0.85
DL	2.052633	k/ft	**L**	16	ft		
LL	2.41425	k/ft					
P	0	k (mid)					

1. Minimum Thickness of Beams/One Way Slabs

ACI Table 9.5(a) L/16 12 in **Deflection OK**

2. Modulus of Elasticity of Concrete

$E_c = 57{,}400\sqrt{f'_c}$ 3630295 psi

3. Deflection at Midspan Due to Distributed Load

❶ $\Delta_1 = \frac{5wL^4}{384E_cI_e}$ .... 0.444242 in

❷ $I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr} \le I_g$ .... 4084.182 in^4

❸ $M_a = \frac{wL^2}{8} + \frac{PL}{4}$ .... 1715.283 k-in

❹ $I_g = \frac{bh^3}{12}$ .... 16128 in^4

❺ $M_{cr} = \frac{f_r I_g}{Y_t}$ .... 637.5152 k-in

❻ $Y_t = \frac{h}{2}$ .... 12 in

❼ $f_r = 7.5\lambda\sqrt{f'_c}$ .... 474.3416 psi

❽ $I_{cr} = \frac{b}{3}x^3 + (n-1)A'_s(x-d')^2 + nA_s(d-x)^2$ .... 3432.376 in^4

Determine Neutral Axis

❾ $b\frac{x^2}{2} + (n-1)A'_s(x-d') - nA_s(d-x) = 0$ 5.120533 in

$\Delta_2 = \frac{PL^2}{48E_cI_e}$ 0 in

4. Total Immediate Deflection

$\Delta_1 + \Delta_2 =$ 0.444242 in

5. Allowable Deflection

L/360 0.533333 **Beam Passes**

Appendix I Pile Cap Design

Pile Cap Design

Col. DL	300	k	Col. Size	324	in^2	H	3.5	ft
Col. LL	350	k	Pile Dia.	16	in			
Mdx	40	k-ft	Pu	125		b	5	
Mdy	80	k-ft	P	50		Vu	150	
Mlx	35	k-ft	f'c	3000	psi	d	2.5	
Mly	65	k-ft	fy	60	ksi	Mu	650	

1. Total Service Load

P=Pd+Pl 650 k

2. Estimate Number of Piles

n=P/Pc 5.2

n= 6

3. Minimum Spacing

s=d*n/2 48 in

4 ft

4. Shear Strength

$$\varphi V_c = 0.85\left[\sqrt{f'_c} + 0.1\sqrt{f'_c}\left(\frac{V_u d}{M_u}\right)\right]bd$$

615.5296

5. Design Reinforcement in Short Direction

$$R_n = \frac{M_u}{0.9bd^2}$$

23.11111 ksi

m 23.52941

$$\rho = \frac{1}{m}(1 - \sqrt{\frac{1-2mR_n}{f_y}})$$

0.000387

$$\rho_{min} = 4/3\rho$$

0.000516

0.002 Use this value

As 3.6 in^2

Use 6#7 3.6

6. Design Reinforcement in Long Direction

Rn 115.5556

rho 0.001972

rho min 0.002629

As 4.731985 in^2

Use 8#7 4.8 in^2

Appendix J Pile Design

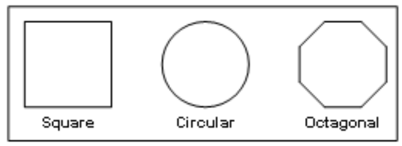
Precast/Prestressed Concrete Inst.
209 West Jackson Blvd. Chicago, IL 60606
Email: info@pci.org
Ph. 312.786.0300
Fax 312.786.0353
Web www.pci.org

JOB:	Robert Moses State Park Bathhouse		1 SHEET OF 4
SUBJECT:	Prestressed Piling Design		
DES. BY:	C.J.F.	DATE: 2/10/2016	
CHK. BY:	L.D.A.	DATE:	

Prestressed Concrete Piling Design - Input

Pile Information:

Use Library Section or Enter Custom Properties



Section Type:	Circular		
Solid/Hollow:	Solid		
Pile Size:	12.00	in.	
Void Diameter:		in.	
Chamfer:		in.	
Unsupported Length, ℓ =	40.0	ft	Unsupported Length of Pile for Slenderness Evaluation
k =	0.80		Effective Length Factor
Applied Dead Load =	20.0	kips	Applied Dead Load on Pile from Structure

Reinforcement:

Pretensioned Strands:

Diameter of Pretensioned Strands	=	0.6	in.	Typically, 0.5 in. dia.
Area of Strand, A_{ps}	=	0.217	in^2	
Strand Layout	=	Circular		
Number of Strands	=	14		
Strand Modulus, E_{ps}	=	28,500	ksi	
Strength of Strand, f_{pu}	=	270.0	ksi	Stress-Strain Information for 270 ksi only
Fraction of f_{pu} used for Initial Stress	=	0.75		
Initial Strand Stress, f_{po}	=	202.5	ksi	

Mild Reinforcement (Spiral/Ties):

Spiral or Ties	=	Spiral	
Wire or Bar Size	=	W3.4	
Wire or Bar Diameter	=	0.208	in.
Minimum Cover to Face of Spiral/Tie	=	2.50	in.

Concrete Properties:

Concrete Strength at Transfer, f'_{ci}	=	4.00	ksi	
Specified Concrete Strength f'_c	=	6.00	ksi	
Concrete Unit Weight, w_c	=	0.150	kcf	
Ambient Relative Humidity, H	=	75	%	(Used for Shrinkage Loss)
Concrete Ultimate Strain, ε_{cu}	=	0.003	in./in.	

Resistance Factors & Slenderness:

Resistance Factor for Flexure, ϕ_{Flex}	=	1.00
Resistance Factor for Compression, ϕ_{Comp}	=	0.75
Method used for Slenderness Calculations	=	ACI

Design Points (Optional):

P_u (kips)	105					
M_u (k-ft)	10					

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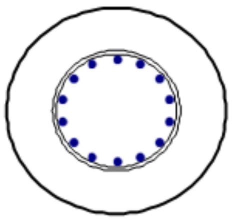
Precast/Prestressed Concrete Inst.
209 West Jackson Blvd. Ph. 312.786.0300
Chicago, IL 60606 Fax 312.786.0353
Email: info@pci.org Web www.pci.org

JOB:	Robert Moses State Park Bathhouse		
SUBJECT:	Prestressed Piling Design		
DES. BY:	C.J.F.	DATE:	2/10/2016
CHK. BY:	L.D.A.	DATE:	

Prestressed Concrete Piling Design - Output

12 in. Solid Circular Pile

14 - 0.6 in. Dia Strands with W3.4 Spiral



Gross Area, A	=	113.1 in^2	
Moment of Inertia, I	=	1,018 in^4	
Radius of Gyration, r	=	3.00 in.	
Unsupported Length, ℓ	=	40 ft	(Input)
Effective Length Factor, k	=	0.80	(Input)
$k\ell/r$	=	128.0	
Applied Dead Load	=	20.0 kips	(Input)
Concrete Unit Weight, w_c	=	0.150 kcf	(Input)
Ambient Relative Humidity, H	=	75 %	(Input)
Concrete Ultimate Strain, ε_{cu}	=	0.003 in./in.	(Input)
Concrete Strength at Transfer, f'_{ci}	=	4.00 ksi	(Input)
Specified Concrete Strength f'_c	=	6.00 ksi	(Input)
Strand Modulus, E_{ps}	=	28,500 ksi	(Input)
Area of Strand, A_{ps}	=	0.217 in^2	(Input)
Strength of Strand, f_{pu}	=	270 ksi	(Input)

Prestress Loss and Effective Stresses:

Initial Strand Stress, f_{po}	=	202.5 ksi	(Input)
Initial Loss, Δf_{pIL}	=	28.3 ksi	
Effective Stress in Strands after Transfer, f_{pi}	=	174.2 ksi	
Effective Prestress Force in Strands after Transfer, F_{pi}	=	529.2 kips	
Total Loss, Δf_{pTL}	=	94.7 ksi	
Effective Stress in Strands after All Losses, f_{pe}	=	107.8 ksi	
Effective Prestress Force in Strands after All Losses, F_{pe}	=	327.4 kips	

Effective Prestress in Concrete:

Effective Prestress in Concrete Pile, f_{pc}	=	2.895 ksi	$= F_{pe}/A$

Concrete Cover:

Concrete Cover to Spiral	=	2.50 in.	(Input)
Concrete Cover to Strands	=	2.71 in.	

Design Points as Input:

	Axial Load (kips)	Moment (k-ft)	Max. Moment w/ Slenderness (k-ft)
1	105	10	17.9
2	0	0	66.2
3	0	0	66.2
4	0	0	66.2
5	0	0	66.2
6	0	0	66.2

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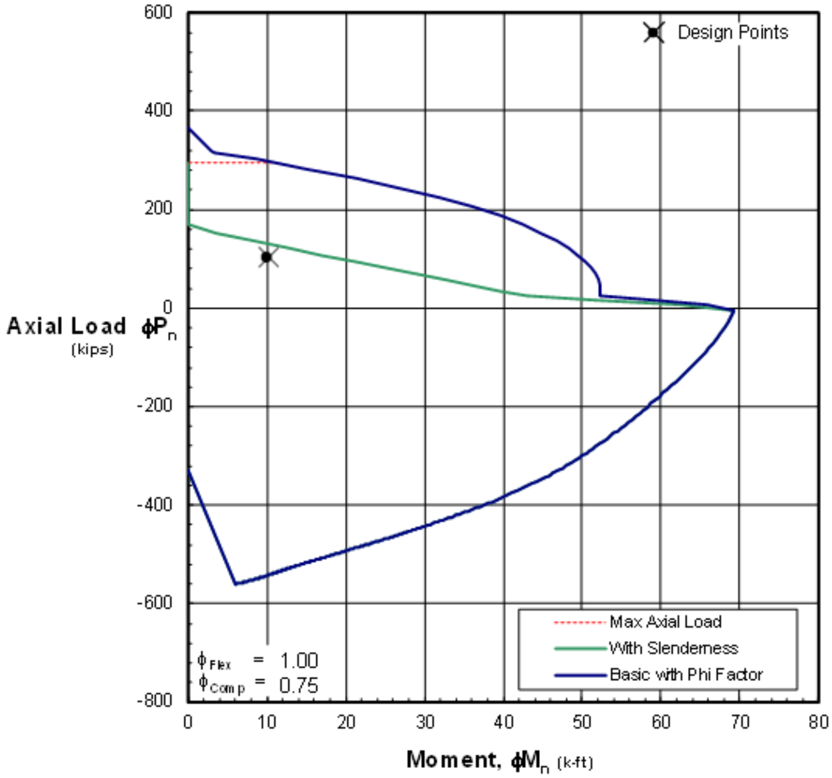
Prestressed Concrete Piling Interaction Diagram

12 in. Solid Circular Pile

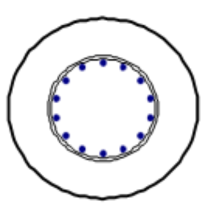
14 - 0.6 in. Dia. Strands f'c= 6 ksi

ACI Method for Slenderness, kl/r = 128



Key Points on Basic Interaction Diagram including φ Factors:

Cross-Section



	Axial Load, ϕP_n (kips)	Moment, ϕM_n (k-ft)
Pure Compression	368.2	0.0
Maximum Axial Load	294.5	11.2
Maximum Moment*	24.8	52.3
φ Break Point	24.8	52.3
Pure Bending	0.0	69.3
Maximum Tension	-560.2	6.0
Pure Tension	-327.4	0.0

* Based on point of maximum moment before φ factors are applied

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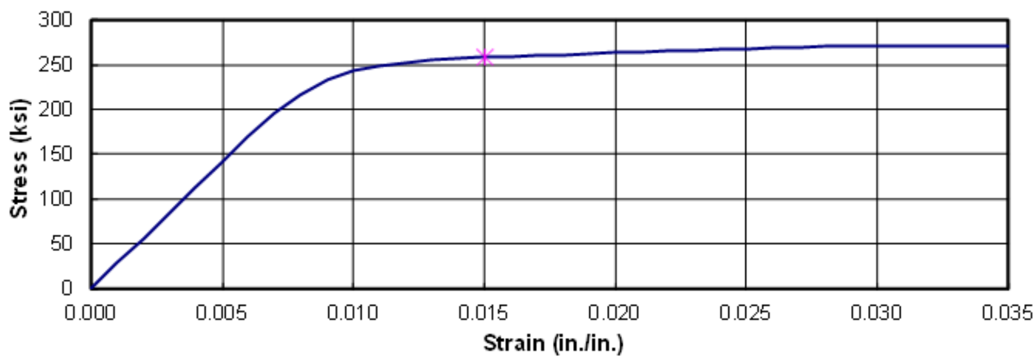
Chicago, IL 60606 Fax 312.786.0353
Email: info@pci.org Web www.pci.org

JOB:	Robert Moses State Park Bathhouse		4 SHEET OF 4
SUBJECT:	Prestressed Piling Design		
DES. BY:	C.J.F.	DATE:D 2/10/2016	
CHK. BY:	L.D.A.	ATE:	

Stress-Strain Curve
270 ksi Low Relaxation Strand
(PCI BDM Eq 8.2.2.5-1)



Strain (in./in.)	Stress (ksi)
0.0000	0.0
0.0010	28.5
0.0020	57.0
0.0030	85.5
0.0040	114.0
0.0050	142.2
0.0060	169.8
0.0070	195.4
0.0080	217.0
0.0090	232.8
0.0100	243.0
0.0110	249.1
0.0120	252.8
0.0130	255.2
0.0140	256.9
0.0150	258.3
0.0160	259.4
0.0170	260.5
0.0180	261.4
0.0190	262.4
0.0200	263.3
0.0210	264.2
0.0220	265.1
0.0230	266.0
0.0240	266.9
0.0250	267.8
0.0260	268.7
0.0270	269.6
0.0280	270.0
0.0290	270.0
0.0300	270.0
0.0310	270.0
0.0320	270.0
0.0330	270.0
0.0340	270.0
0.0350	270.0

Compute Stress

Strain (in./in.)	Stress (ksi)
0.0150	258.27

$$f_{si} = \varepsilon_{si}[887 + 27,613/\{1 + (112.4\varepsilon_{si})^{7.36}\}^{1/7.36}] \leq 270 \text{ ksi}$$

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Pile Design

fc'	4000	psi	Ast	2.64	
fy	60000	psi			
Ac	201.0619	in^2	Acore	132.7323	
r	8	in	Cover	1.5	in

Concrete Filled Shell No Confinement

Pa=	257359.3	lbs
	257.3593	kips

Precast Reinforced

Pa=	327177.7	lbs
	327.1777	kips

Allowable

Pu	200	kips	
ΦPu	150	kips	Passes

Area of Steel

$$\rho_s = 0.45\frac{f'_c}{f_y}(\frac{A_g}{A_{core}} - 1)$$

		0.015444	
		3.105158	in
Use	6#6	2.64	

Min

0.008	
1.608495	in

Appendix K Project Proposal

A Major Qualifying Project:

Field 5 Bathhouse Project Proposal

Robert Moses State Park – Fire Island, Babylon, NY

January 13, 2016

Christopher Flanagan '16

Rachel Kennedy '16

Worcester Polytechnic Institute

Introduction

Construction projects require the expertise of various disciplines in engineering. New construction and renovation projects involve specific challenges and requirements. The role of the structural engineer and the architectural engineer is particularly crucial to the success of a building project. The fields overlap in many regards, but require an understanding of one another at all phases of the project.

The Field 5 Bathhouse project requires structural and architectural engineers to undergo design for both new construction and renovation. The collaboration between the disciplines can be enhanced with the use of Building Information Modeling (BIM). As a practical design tool and an essential construction tool, BIM will provide a commonplace for all aspects of the Bathhouse project.

BIM will be used in the Field 5 Bathhouse for visualization and adaption of the building model, analysis of the structural components of the foundation and slab on grade in the structural model, and calculation of the energy savings with the energy model.

Stantec will be submitting the 100 percent design of the Field 5 Bathhouse near the start date of this project (1/14/2016). As a result, our analysis and design will have limited influence on the Field 5 Bathhouse project; however, our work will provide Stantec and New York State Office of Parks, Recreation, and Historic Preservation with recommendations for the Field 2 Bathhouse, which is expected to undergo renovations in the near future that will be similar to those of the Field 5 facility.

The architectural engineering components include creating an energy model, and developing alternative designs for the expanded women's fixture count and exterior aesthetics. The structural engineering facets include the design and analysis of the foundation, masonry walls, two porticos, and the roof system.

Background

Overview of Field 5 Bathhouse

The Field 5 Bathhouse building was designed in September 1970 and is presumed to have opened within the next 18- to 24-months. The bathhouse building is fully operational during the summer months, and has public toilet room facilities open for fisherman during the early spring and late fall.

The existing building is a two-story, pile-supported T-shaped building with detached locker/shower structures on the east and west sides. Floors are concrete slab-on-grade, and walls are constructed of concrete masonry, structural glazed tile, and brick masonry. The roof structure is wood-framed with wood sheathing and architectural-grade asphalt shingles.

The Field 5 Bathhouse Renovation Project includes both new construction and renovation work, detailed in Table 1 below.

Table 1: Field 5 Bathhouse Project Scope

	Renovations	New Construction
Field 5 Bathhouse Project Scope	All interior spaces, with limited renovations in kitchen and dining areas Exterior renovations, including replacement of exterior fenestration and localized masonry repairs Public toilet rooms Staff toilet rooms First aid office and area office	MEP system Fire alarm system Detached shower areas Porticos

This chapter provides more detail on the parts of the Renovation Project that our project will specifically focus on.

The Field 5 Bathhouse Basis of Design

The background research on the Field 5 Bathhouse is from the Basis of Design document submitted by FST. The document is for the 95 percent submission of the final design. The provided information will be updated to include the 100 percent submission to reflect any changes or additions to the project.

(A-1) Develop Alternative for Women's Public Shower Area

The alternative (Alternative 2A) selected by OPR&HP for the Women's Public Shower Area maintains the new structure within the current 33'-4" x 44'-4" footprint of the existing structure. The amenities provided are 9 public shower stalls, 7 public dressing cubicles/compartments, 13 toilets, and 7 lavatories.

(S-1) Design of Foundation Systems

The proposed foundation system of the Field 5 Bathhouse is pile-supported grade beams and a slab on grade. The design specifies 40-ft friction piles of 8-inch diameter. The Basis of Design determines that the piles must have a 20-ton bearing capacity and follow BCNYS 1808 and 1809.

The proposed grade beam will be reinforced concrete with a compressive strength of 4,000 psi after 28 days. The reinforcement will be steel with yield strength of 60,000 psi. The grade beam will sit on a 6" gravel base that is excavated from the sub base.

The slab on grade will be replaced with a 5" reinforced concrete slab with a compressive strength of 4,000 psi at 28 days. The reinforcement for the slab will have yield strength of 60,000 psi. The slab will be thickened under the walls and columns.

(S-2) Analysis of Masonry Assemblies

The existing public shower area of the Field 5 Bathhouse as well as the main building consists of load bearing masonry walls. The Basis of Design acknowledges that the chosen alternative design calls to increase the size of the floor plan. As a result, the plan calls for additional masonry walls, which will support the expanded roof.

(S-3) Design of Entrance Porticos

There are two porticos under the scope of the Field 5 Bathhouse project that are to be constructed. Steel columns that are encased in concrete support the portico designs for the Field 5 Bathhouse. The columns are wrapped with face brick and "hardie" board.

(S-4) Design and Analysis of Roof Structures

The scope of work contains the construction of a new roof structure that extends beyond the existing roof footprint. The roof structure is a wood-framed hipped roof. Based on the Basis of Design, the roof live load is anticipated to be 20 psf.

Sister Bathhouse: Field 2 Bathhouse

Constructed approximately two years prior to Field 5 Bathhouse, Field 2 Bathhouse is located less than a mile to the west and is virtually identical to Field 5. The client is interested in renovating this bathhouse at some future time. Our project will focus on developing recommendations for Field 2 Bathhouse as we work on the Field 5 Bathhouse Renovation Project. This will aid Stantec in devising the Field 2 Bathhouse project's design scope.

Methodology

The purpose of this project is to develop architectural and structural recommendations based on the renovation of the Field 5 Bathhouse for the future renovation of its sister bathhouse, the Field 2 Bathhouse. Stantec is submitting the 100% design documents for the Field 5 Bathhouse within days of our project start; therefore, our project will focus on changes that can be applied to the Field 2 Bathhouse and play a role in devising that project's design scope.

Our project methodology has three main parts: to develop building, structural, and energy models that can be adapted and extended as the project evolves; to design architectural alternatives for the expanded women's fixture count and a higher-end exterior aesthetic for the bathhouse; and to analyze and evaluate alternative designs for the foundation, masonry, roof, and porticos. This chapter further describes how our team will accomplish each of these tasks and concludes with a tentative project work schedule.

Computer Models

Building Model

A 3D building information model of the Field 5 Bathhouse will be created in Autodesk Revit to provide the Stantec and the New York State Office of Parks, Recreation, and Historic Preservation with an adaptable model. The model will allow visualization, scheduling, material takeoffs, budgeting, and provide a basis for additional computer-based integrations such as structural and energy analysis. The Revit model will be based on the 100 percent design of the Field 5 Bathhouse as prepared by Stantec.

Structural Model

The structural model of the bathhouse will utilize RISA for the structural components that are composed of concrete. The model will provide analysis of the proposed structural components of the foundation and slab on grade as defined by the 100 percent design, as well as alternatives that can be used for the Field 2 Bathhouse.

Energy Model

Our team will create an energy model to calculate the energy savings of the Field 5 Bathhouse. Based on the energy simulations, we will recommend design solutions for reducing energy consumption in the Field 2 Bathhouse. The energy model will also be created in a way that it can be updated and adapted as changes are decided for the Field 2 Bathhouse.

Our team will use established methodologies for creating the energy model. The input data and underlying algorithms will come from reliable, well established, and published sources and the simulation model will be validated to ensure accuracy and precision (Kilkis, 2007). Initial data input will come from Stantec's Field 5 Bathhouse 100% design submission and original design and construction documents, as available. ASHRAE standards for load and energy calculations will be used for load and energy calculations when other data is not provided. The following six stages outlines the process we will use to develop the energy model in eQuest, Stantec's in house software (Lindauer, 2015):

1. Determine of the location of the building site so that the model can be linked to location-specific climate information
2. Define the geometry, constructions, materials and spaces of the building
3. Assign of the space objects to thermal zones
4. Allocate of space and lighting loads
5. Define of the technical building systems and their components
6. Execute of energy simulation

Building geometry, building systems and material properties, site conditions, and building operation information are defined when creating a BIM model. However, there is limited exchange between BIM software and energy modeling software, and as a result the virtual building is susceptible to errors for energy analysis (Kilkis, 2007). Therefore, we will validate the energy model with utility bills and energy audits to ensure that the simulations accurately reflect the building's energy performance.

Architectural Design

(A-1) Expanded Women's Fixture Count

The new public toilet facilities layout for the Field 5 Bathhouse was primarily developed by the architectural engineer to update the public facilities and provide additional public toilets for women. Constrained by the inability to reduce the number of women's showers and the need to meet accessibility code requirements for all public design elements, there is an opportunity to improve upon the expanded women's fixture count that was derived.

Our team will create an alternative for the expanded women's fixture count by (1) gathering information about the current design, (2) establishing criteria for the new design, and (3) evaluating alternative designs based on the established criteria. We will talk with the architectural engineer to understand the important points of the space planning exercise. From the discussion, our team will create a list of requirements versus requests to determine the criteria for design. Finally, an alternative design will be selected according to the established criteria.

(A-2) Higher-end Exterior Aesthetic

The current Field 5 Bathhouse exterior aesthetics were primarily client-driven and minimal, due to limited funding. Thus, the goal of this task is to develop a higher-end exterior aesthetic that would create more visual interest.

Our team will develop this higher-end exterior aesthetic by (1) identifying the client's desire for the Bathhouse appearance, (2) researching stylistic themes including nautical and Long Island themes, (3) proposing alternative aesthetic designs for the Bathhouse, and (4) calculating the cost of the new higher-end exterior aesthetic designs. Our team will identify the client's intended appearance of the Bathhouse through discussions with Stantec's architectural engineers. Research will be conducted on stylistic themes for Bathhouses, public beach facilities in Long Island, and similar nautical and Long Island-themed buildings for inspiration to create a new look for the Field 5 Bathhouse and Field 2 Bathhouse. Our team will then propose alternative designs to the client including the costs of choosing a certain design.

Structural Design

The structural design of the Field 5 Bathhouse will be reviewed to determine where, if any, improvements can be made. The objective of the structural design and analysis of the Field 5 Bathhouse designs is to provide alternatives for the similar Field 2 Bathhouse that is slated for future renovations. If possible, the structural analysis will provide alternatives for the Field 5 Bathhouse.

(S-1) Design and Analysis of the Foundation

The proposed foundation design of the pile foundation, grade beams, and slab on grade will be analyzed. Due to the scope of the project involving a larger roof footprint, there are plans for additional wood piles to support grade beams. Alternative pile foundations will be explored, such as precast piles, to determine if improvements can be made. The precast design will follow the PCI Design Handbook ("PCI Design Handbook," 2010), as well as the ASCE approach for precast prestressed pilings (*A Simplified Design Procedure for Precast Prestressed Concrete Piling in Areas of High Seismicity to Include the Effects of Pile Buckling)(Mays, Black, & Foltz).*

(S-2) Design and Analysis of the Masonry Assemblies

Analysis of reinforced masonry walls will be performed to provide insight into the performance of the load bearing walls with the proposed expanded roof. This analysis will be performed with RISA structural software. Alternatives will be designed using *ACI Building Code Requirements and Specification for Masonry Structures* (ACI/ASCE/TMS, 2011) and analyzed with RISA.

(S-3) Design and Analysis of the Porticos

The portico design will be analyzed to determine where improvements can be made and alternatives to the steel column design will be explored. Alternative designs will be based on load capacity, material composition (to improve longevity based on the location), and aesthetic design. Additionally, the portico design provided in the 100 percent design, as well as any alternatives, will be modeled through RISA to determine the structural analysis.

(S-4) Design and Analysis of the Roof System

The roof of the Field 5 Bathhouse will be reviewed to design and evaluate alternative solutions based on structural performance, cost, and longevity. The current options to evaluate are wooden truss, stick frame, and engineered lumber. The design and analysis of the alternative roof designs will be based on the *National Design Specification for Wood Construction 2015 (ANSI/AWC, 2015)*.

Schedule

The following schedule outlines the project activities and milestones. It includes the Office Orientation, the BIM component, the Architectural Design/Analysis, the Structural Design/Analysis, and the Project Report. The start date is January 14, 2016 and the end date is March 4, 2016. The schedule reflects business days. The schedule will be updated and amended on a weekly basis to ensure the project will be completed by March 4, 2016.

Bathhouse Rennovation Project

Chris Flanagan and Rachel Kennedy

Start Date: January 14, 2016

Tasks	% Done	Start	End
Project	**0%**	**Jan-14**	**Mar-4**
Stantec/Office Orientation	0%	Jan-14	Jan-15
BIM	**0%**	**Jan-19**	**Feb-3**
Revit Model	0%	Jan-19	Jan-22
Risa Model/Analysis	0%	Jan-25	Jan-28
Energy Model/Analysis	0%	Jan-22	Feb-3
Design/Analysis of Architectural Alt.	**0%**	**Feb-4**	**Feb-19**
Expanded Women's Fixture Count	0%	Feb-4	Feb-11
Higher-end Aesthetic	0%	Feb-12	Feb-19
Design/Analysis of Structural Alt.	**0%**	**Jan-29**	**Feb-19**
Foundation Design	0%	Jan-29	Feb-5
Masonry Assemblies	0%	Feb-5	Feb-9
Portico Design	0%	Feb-8	Feb-12
Roof Design	0%	Feb-15	Feb-19
Project Report	**0%**	**Jan-19**	**Mar-4**
Background Revision	0%	Jan-19	Jan-21
Methodology Revision	0%	Jan-20	Jan-26
Results/Conclusion	0%	Feb-22	Feb-25
Final Revisions	0%	Feb-26	Mar-4

d	deadline
w	wip
-	to do
.	complete
x	phase